September 1961

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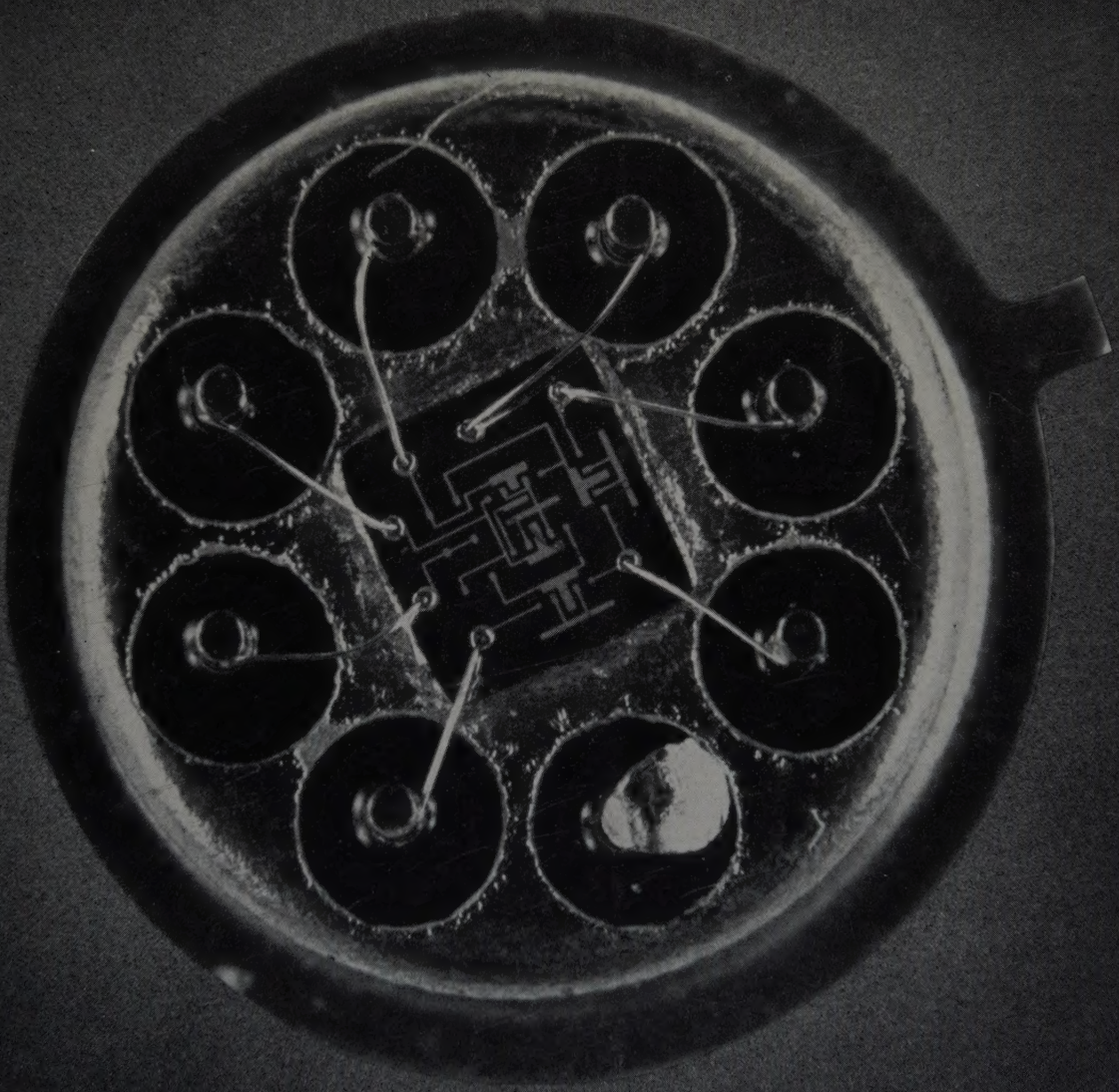

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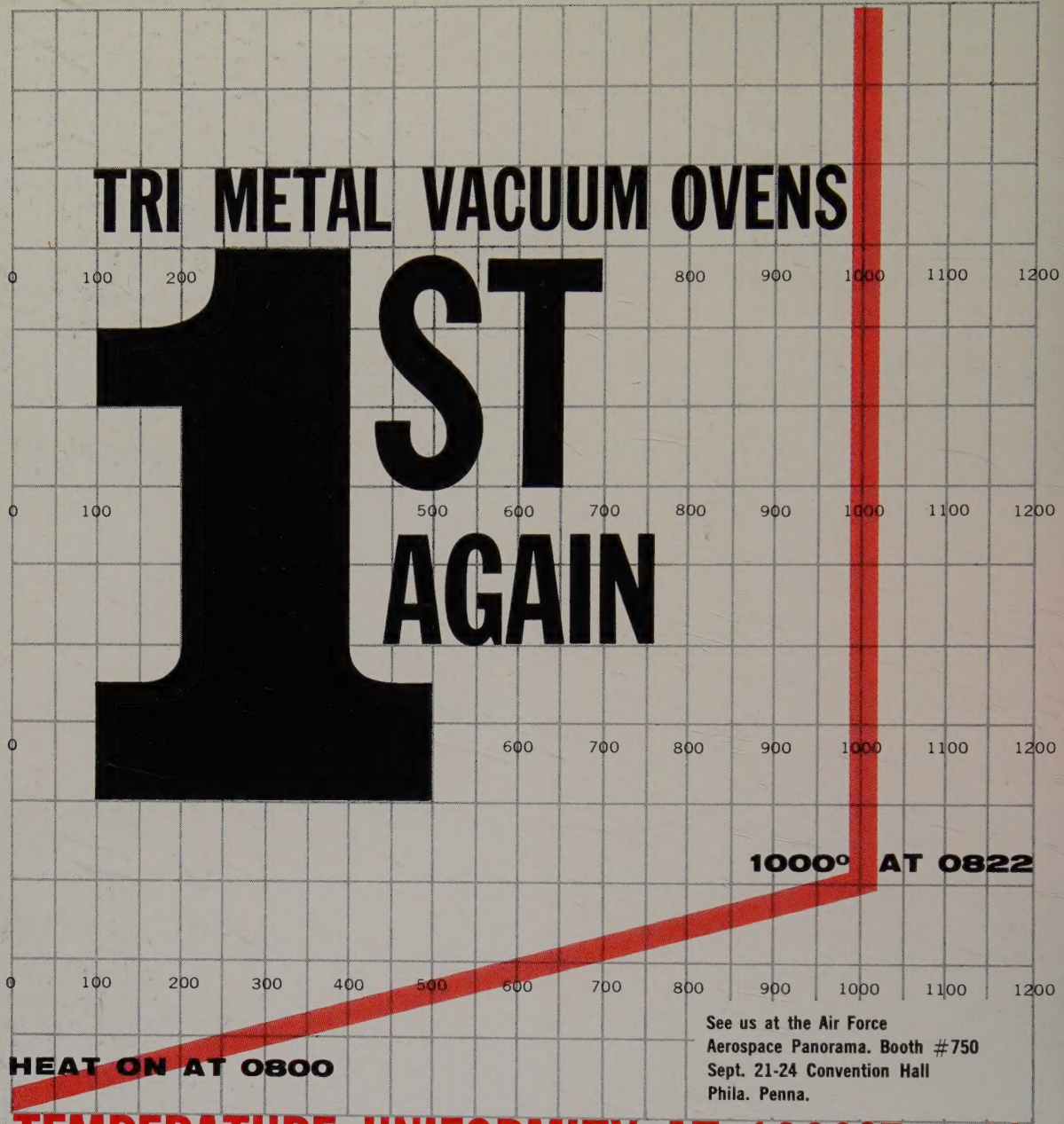

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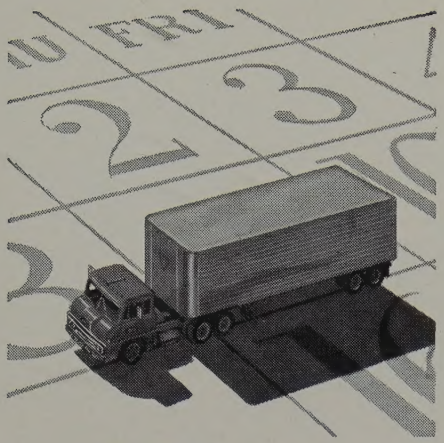

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SEMICONDUCTOR PRODUCTS

SANFORD R. COWAN, Publisher

September 1961 Vol. 4 No. 9

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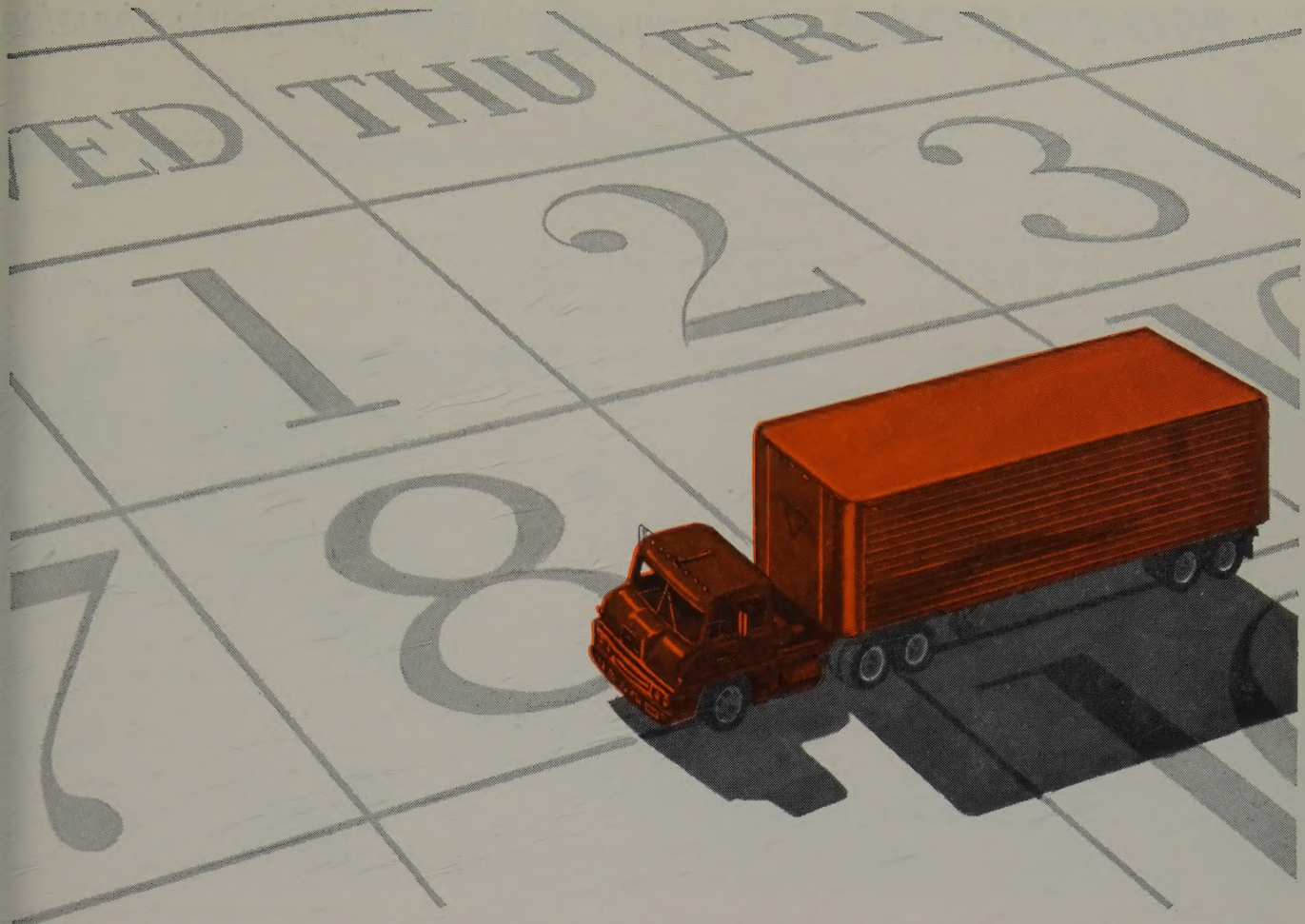
Front Cover

Shown is the uncapped Micrologic Half-shift Register now in production at Fairchild Semiconductor, Mountain View, California. Using this integrated functional digital building block along with other Micrologic elements, computer manufacturers may build the complete logic and control section of a digital computer at reduced size.



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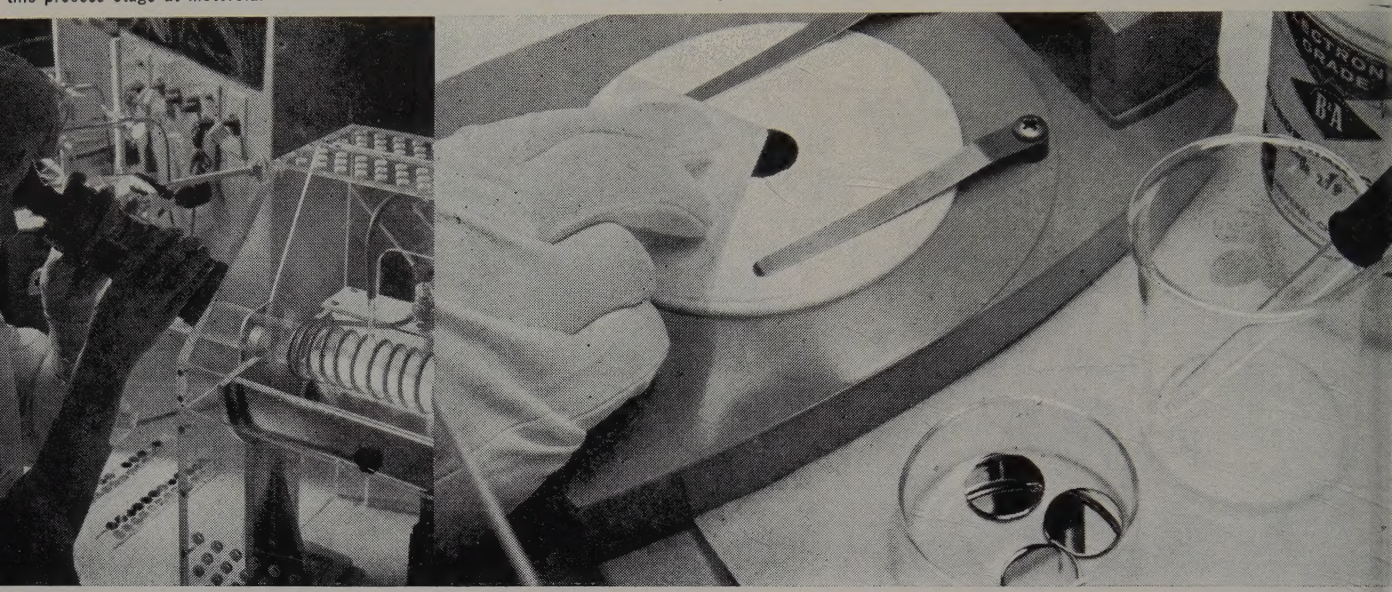

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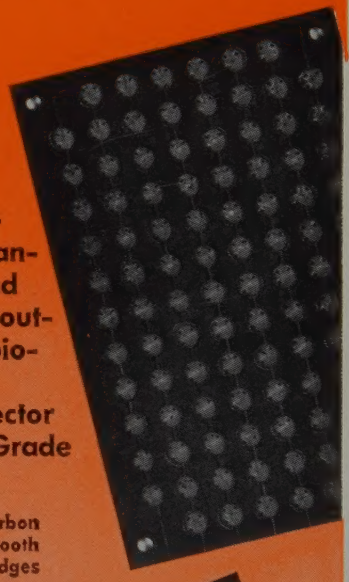

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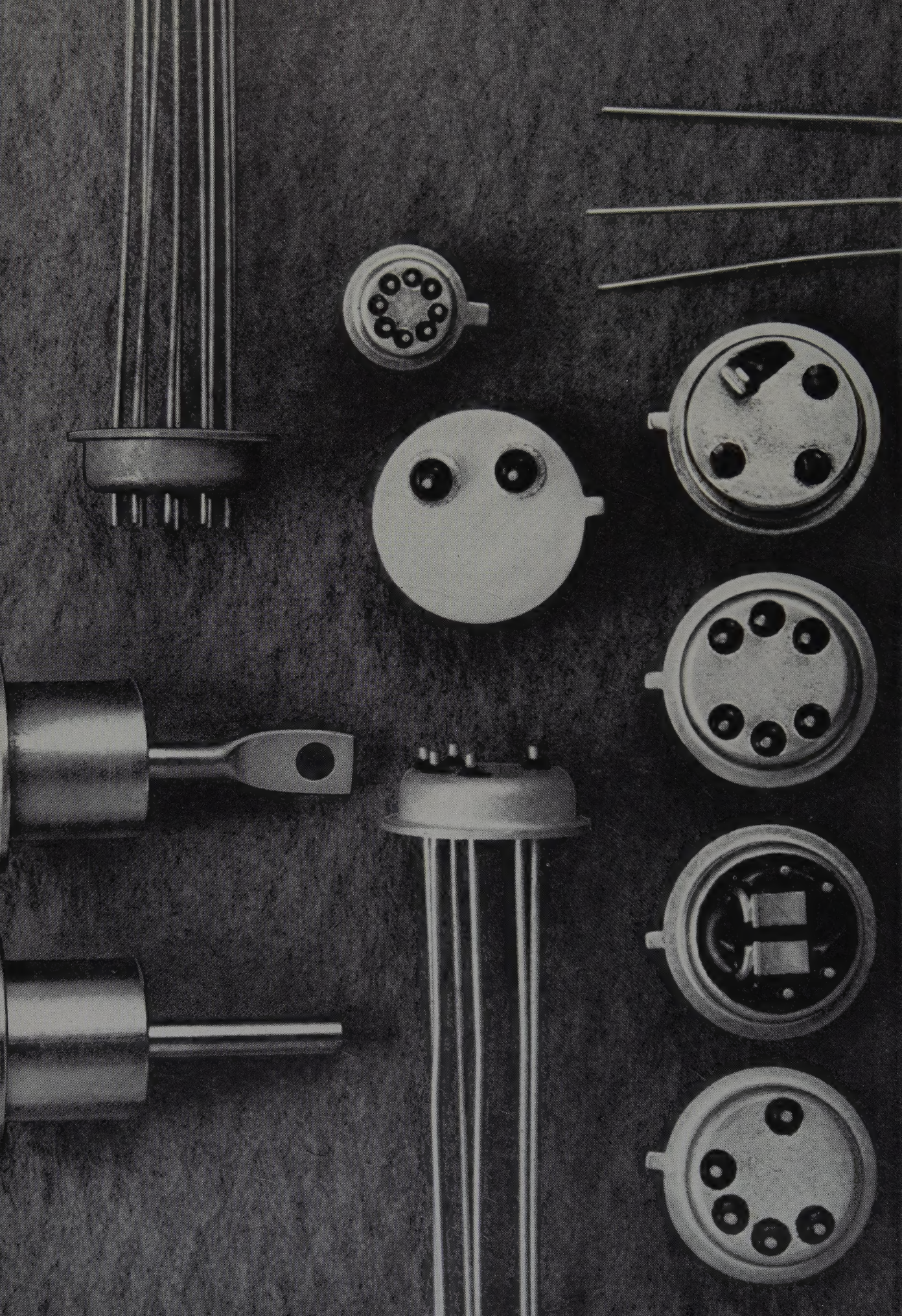

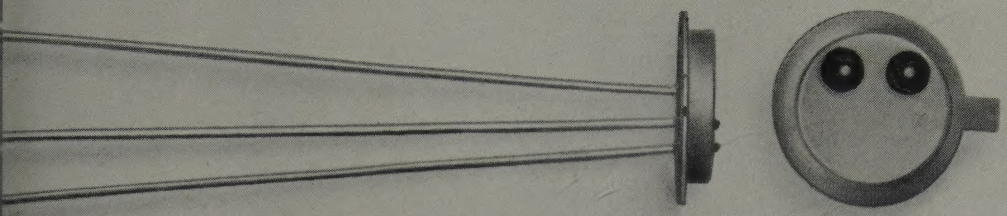

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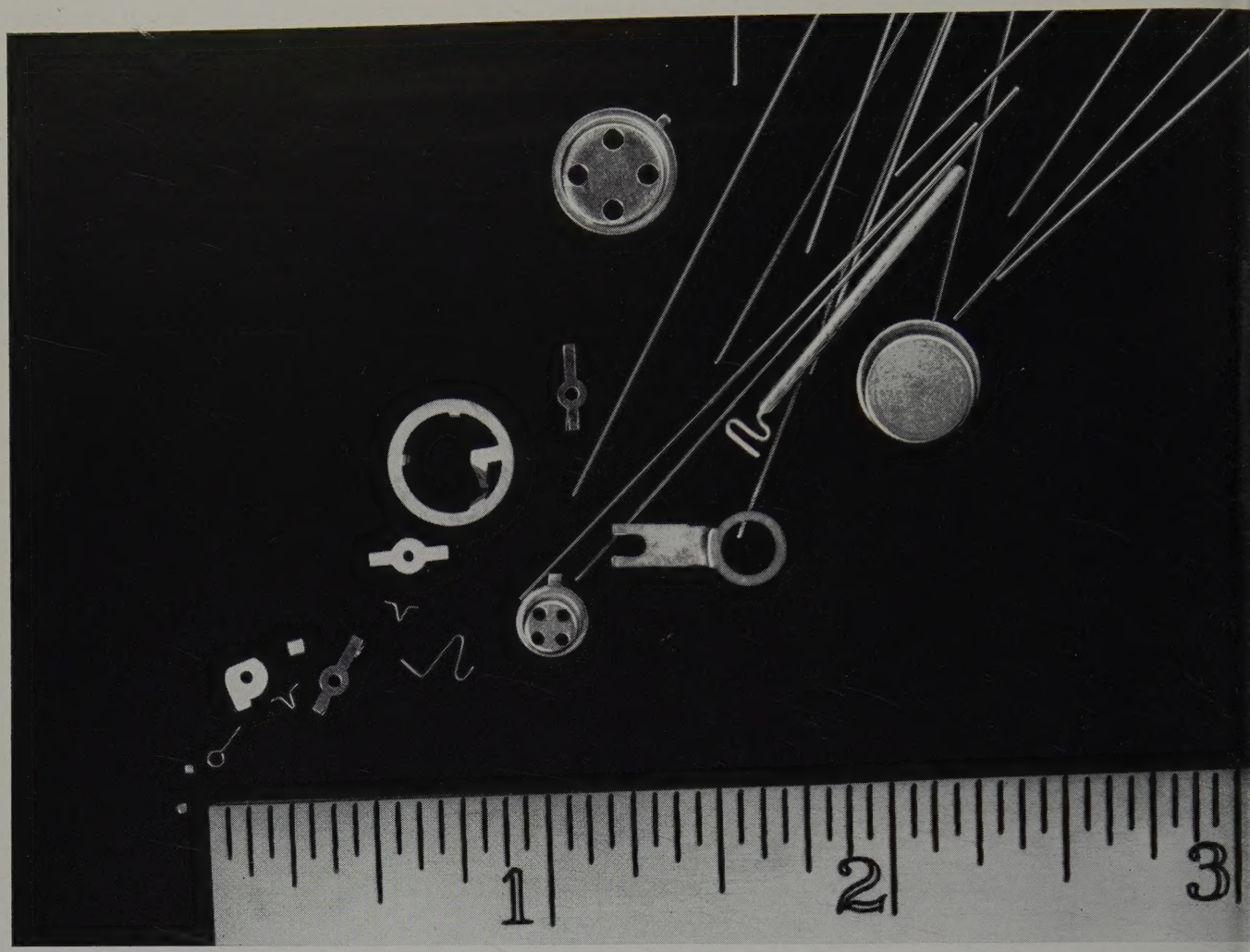

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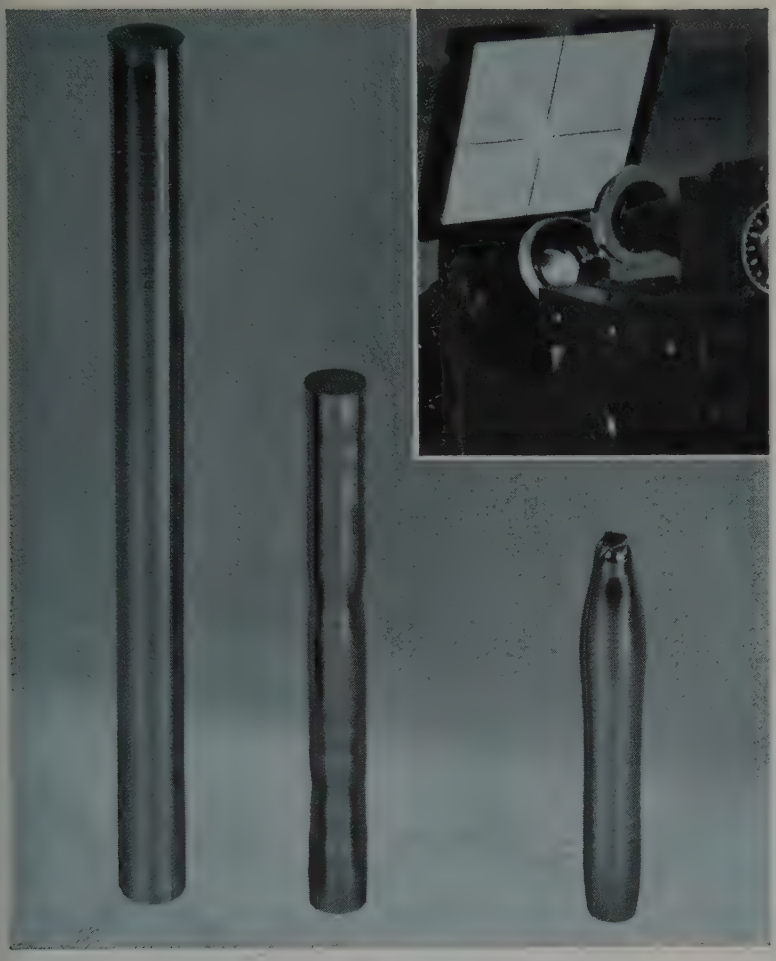

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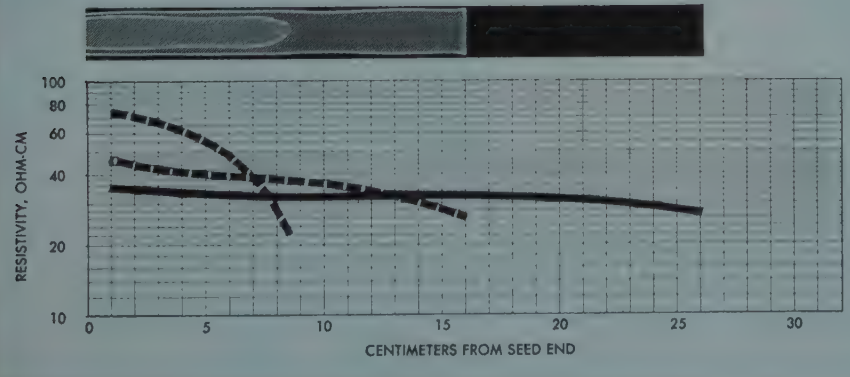

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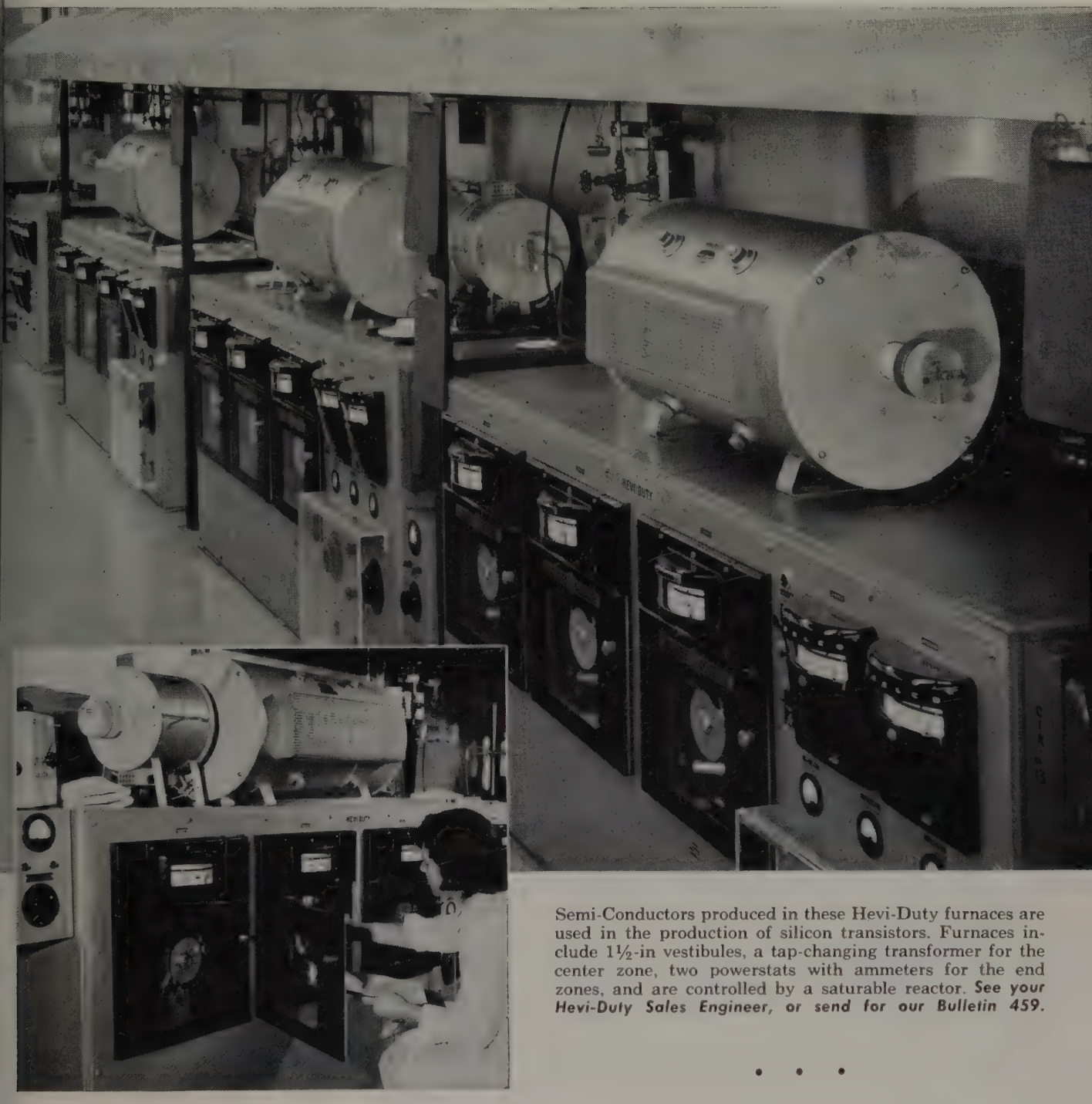

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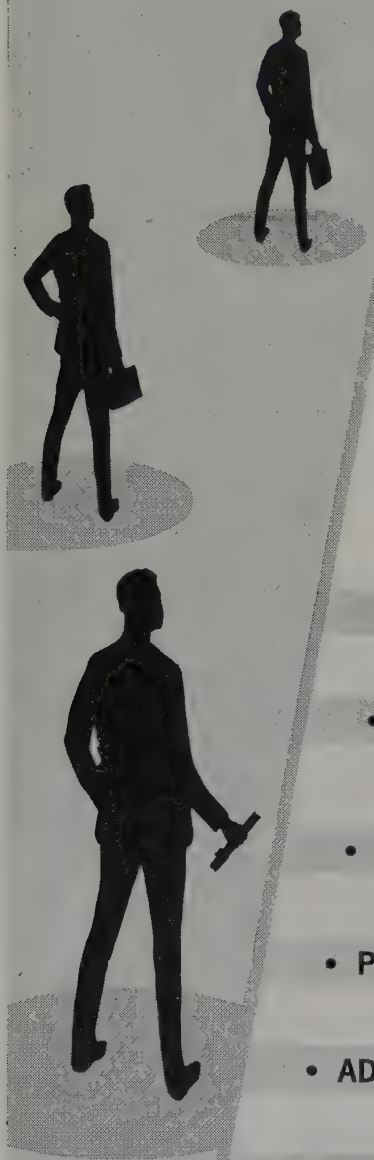

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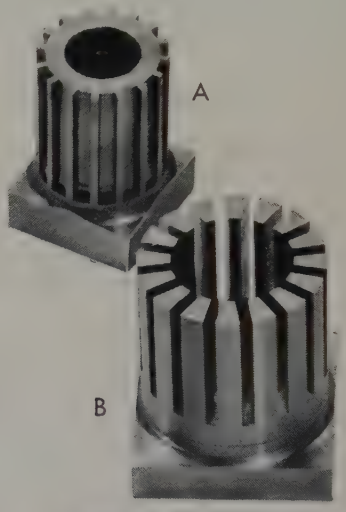
On this Sheffield-Cavitron® Ultrasonic Machine Tool is shown the set-up for machining a motor laminator of ferrite — a material with the hardness of sapphire and the machinability of glass Illustrated separately are a finished laminator and the two cutting tools involved. The smaller tool (A) first machines the small slots around the center of the ⅜" hole in the laminator to a tolerance of ±.001". The larger tool (B) then machines the 16 wedge-shape slots simultaneously, concentric with O.D. and I.D. within .002" T.I.R. "Working" this complex ferrite shape is typical of the capability of Sheffield Ultrasonic machine tools and NORBIDE boron carbide abrasive in broadening the machinability of modern materials.



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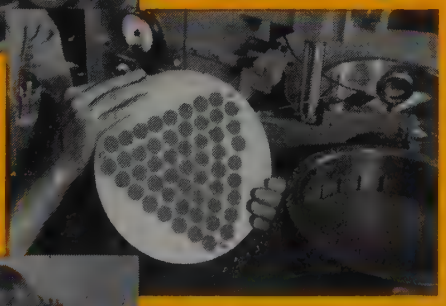

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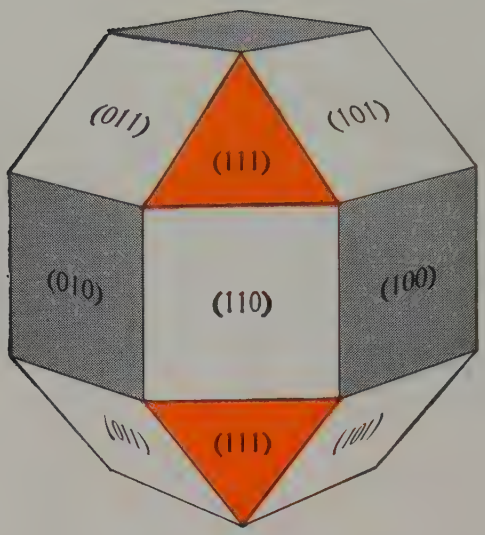

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Editorial . . .

THE STATE OF THE SEMICONDUCTOR BUSINESS

The following remarks were excerpted, in part, from a recent talk given by Mr. Moses Shapiro, President of General Instrument Corporation. We concur whole-heartedly with the opinions expressed.

"Questions have been raised concerning the validity of previous industry forecasts of growth and profitability of the business, analogies with the vacuum tube industry in its early days have been drawn, and, in general, the same kind of intellectual excesses are being engaged in, although now negatively rather than affirmatively as was the fashion during the past several years.

'This latest peak in interest appears to have been triggered by the appearance of the operating results concerning the first calendar quarter of this year of several companies heavily engaged in the semiconductor business.

'While this interest is perfectly valid and justified, it has led to some conclusion-jumping which is not well-considered. . . .

'I do not mean to imply by these comments that the various analyses which have been made recently are without merit or that they do not properly point out the problems and difficulties of the semiconductor business. I do mean that careful and discriminating judgment must be applied, and that it would be just as wrong to conclude that these problems are insuperable as it was to conclude that all that was necessary for fantastic success was to rub a genie's lamp named "Semiconductor."

'The problems facing the industry are real enough. In my judgment, the basic problem is that technological maturation and sophistication have advanced more rapidly than have the business and emotional maturity of some of those in decision-making roles.

'While enlarged capacity, increased competition and a less rapid utilization rate of new and advanced products are all reality factors which tend to create marketing difficulties, none of them, nor all of them together, can wholly account for the utterly absurd rate of price deterioration which has recently afflicted some segments of the business. This result had to be the product of a merchandising, pricing and marketing immaturity which is perhaps inherent in a new industry which has grown as explosively as this one has.

'A proclamation that one will not be undersold by anyone is perhaps appropriate for across-the-street competitors in the department store field, but is hardly appropriate in a business in which scientific research, customer engineering and servicing, strength as a mass source and product reliability should play the crucial roles. Pricing policies apparently unrelated to perhaps unknown true costs hurt a whole industry temporarily, but must inevitably hurt more lastingly those responsible for such policies.

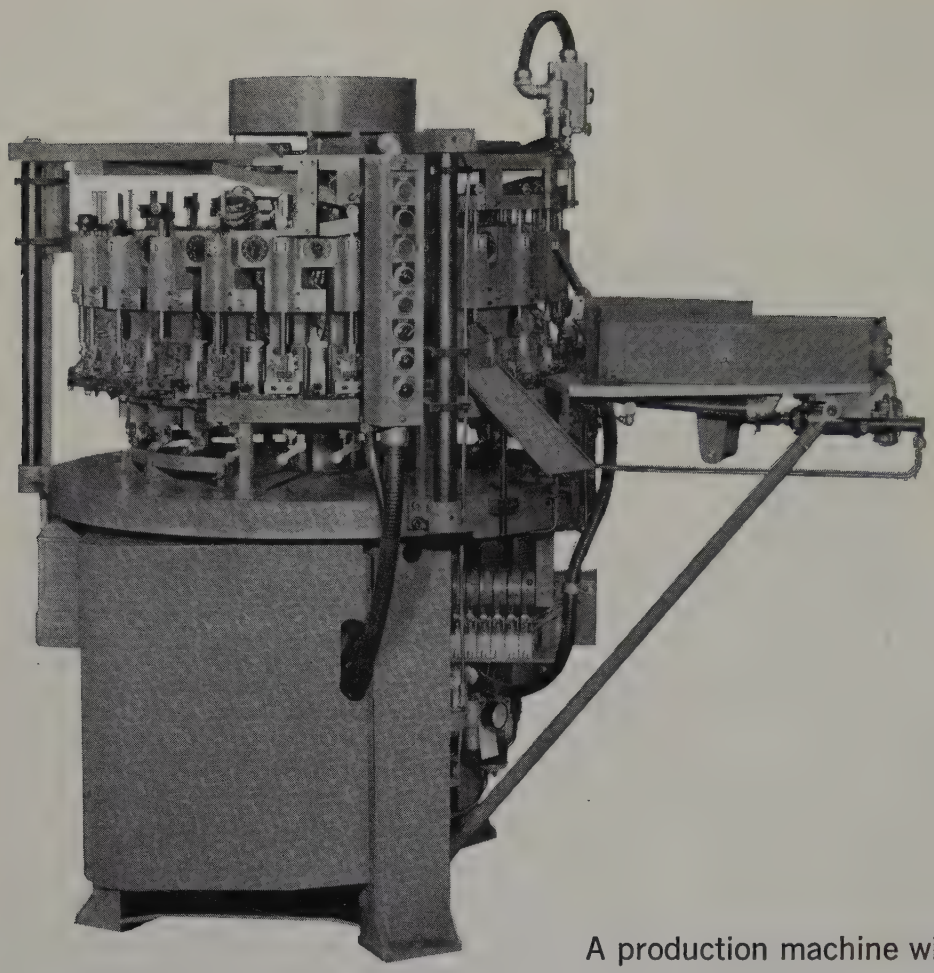
'Our own view of the basic future of the semiconductor business remains unchanged. This is *not* the vacuum tube business all over again. The technological advances of the future will make those that have already taken place seem, in retrospect, like faltering first steps.

'In the predictable future, because of the startling scientific advances which will take place, no small number of giants will gobble up the entire business; the utilization of the devices of the industry will continue to grow at a significant rate; and the predictions of a billion dollar business will come to pass. The competition for the market place, for ideas and for people will continue at a keen pace. There will be those who falter and those who take their place; there will be those who decline and those who prosper.

'But it is in these times that the shape of the future will be able to be discerned by those with keen eyesight and keen insight. Those who panic and contribute to chaos will pay a deserved price; those who retain their senses of balance and judgment, who make sound product and marketing decisions, will survive and grow even though temporarily adversely affected.

'We begin to see even now the first emergence, after the recent hysteria, of some semblance of stability. Some undoubtedly have been sobered by the recent profit and loss results they have seen and are beginning to inquire into the validity of the doctrine of volume at any price. Perhaps now top corporate executives are paying attention to the marketing policies of their divisional management field sales offices. Even some of the major responsible users of these products may well have begun to be concerned whether their long range interests are best served by a seemingly never-ending downward price spiral at a rate which will not support the component research, development engineering and reliability concepts as vital to their product success as it is to those engaged in this business.

'In semiconductors, we ..... are forging ahead—in sales, in product breadth, in technology and manufacturing capabilities, and in customer recognition. While we are not immune to the current situation, we have been and we are operating profitably and expect to continue to do so at satisfactory levels. The intensity and indeed the stupidity of some of the current storms do not dismay us; we're confident that they will subside and when they do we expect to emerge even more solidly entrenched. We welcome the challenge of these times—we're more than willing to match stability, ingenuity, capabilities and imaginative problem solving. We're thinking, building and planning for the long range future and no temporary vicissitudes will deter us. The semiconductor business is a good and growing business with a brilliant future, and generous rewards await those who have the courage and daring to drive ahead. When has America ever rewarded, for long, anyone who has less?"



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Effects Of Heat Treatment On Diffused Silicon Material

A. L. MACDONALD* W. J. HEINECKE†

The effects of post diffusion cooling treatments on several N-type silicon single crystals were investigated. Decreases of electron concentration were noted with heat treatment. Several combinations of cooling, quenching and annealing which lead to similar bulk properties are described. The magnitude of concentration changes are shown to be dependent upon the particular crystal and upon the position within the crystal. The application of these results towards the selection or preparation of material for particular device requirements is discussed.

It is known that the bulk properties of silicon are dependent upon heat treatment; however, most of the information available in the literature treats these properties with respect to crystals rather than with respect to diffused material or devices[1-5]. In the literature, little mention is made of the effects of diffusion on cooling, fabrication heating or the other heating treatments on device characteristics. In an effort to orient these effects more closely to diffusion devices, the following studies were undertaken:

1. The dependence of bulk properties and device characteristics on the diffusion cooling path and rate.
2. The stability of the resulting bulk properties during subsequent device fabrication heating.

It was hoped that these studies would suggest particular heating-cooling treatments which would result in certain desirable combinations of bulk properties.

For the purpose of studying the dependence of bulk properties upon cooling path, two different experimental thermal programs (as shown in Fig. 1) were used. In the first, at the conclusion of heating at 1300°C for 20 hours, the furnace was cooled at a rate of approximately 100°C per hour to a desired temperature (Curve B). At selected temperatures along this curve, slices were removed from the furnace and air quenched to room temperature. These experiments are termed "cool-quench" experiments.

An alternate thermal program was followed (Curve A) whereby, after heating to 1300°C for 20 hours, the material was quenched to a specific annealing temperature and then held at that temperature for a variety of times before removing from the furnace. Slices were then quenched from this temperature at selected times. These experiments are termed "quench anneal" experiments. The dependence upon cooling path was shown by simultaneously programming part of the material along curve A of Fig. 1 and the remainder along curve B of Fig. 1. Of the material following curve B, the first sample was not quenched until the desired annealing temperature was obtained (e.g. 400°C after 9 hours cooling). Materials from the juncture of these two cooling paths were compared.

All crystals used in these experiments were 5 to 10 ohm-cm N type, grown in the <111> direction. They were pulled with a rotation rate of 60 r.p.m. in an argon atmosphere at a rate of 3 inches per hour from a silica crucible.

Cool—Quench

For the cool-quench experiments, 50 mil slices of approximately the same resistivity (a one to two ohm-cm spread) were studied according to position within the crystal. Samples were lapped, solvent cleaned, and given an HF etch before heating. In cases where it was desired to study only bulk properties, no diffusant was used. The samples were loaded in a vertical position onto etched quartz boats and were placed in a furnace.

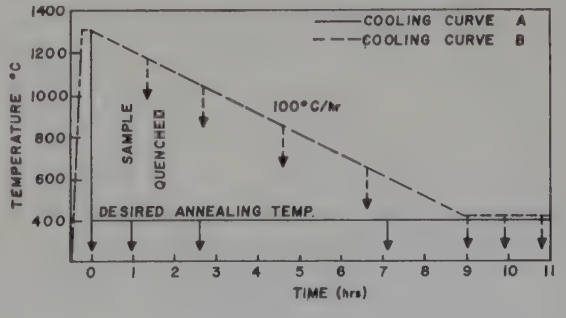

Fig. 1—Experimental cooling programs. Curve A corresponds to the cooling path for the 400°C "quench anneal" experiments; Curve B corresponds to the cooling path for the "cool-quench" and "slow-cool" experiments.

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†Formerly associated with The Semiconductor Division of Raytheon. Now with Electronics Corp. of America, Cambridge, Mass.

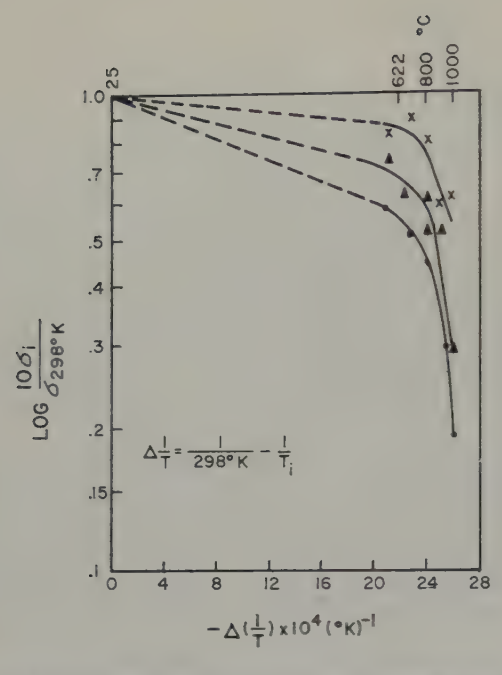

Fig. 2—Log of the ratio of the room temperature conductivity of the material quenched from a particular temperature to the room temperature conductivity of material slow-cooled to room temperature vs.

$$-\Delta(1/T)\times 10^4(°K)^{-1}$$

for three crystals.

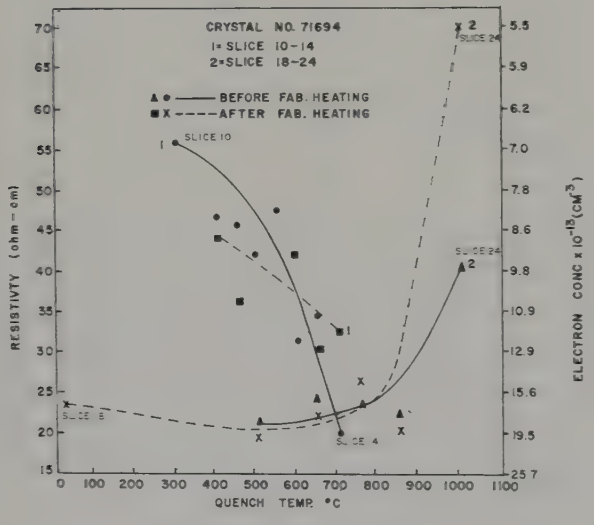

Fig. 3—Dependence of resistivity upon slow cooling to and quenching from the indicated temperatures. Stability upon fabrication heating is shown by comparing the solid with the dotted curves.

The material was heated to and held at 1300°±5°C for twenty or more hours in a flowing argon atmosphere. The longitudinal temperature variation within the furnace control zone was ±1°C.

At the conclusion of the 1300°C heat treatment, the furnace was cooled at a rate of 100°C/hr. Samples were removed and air quenched at various temperatures along the cooling curve. The estimated time to reach room temperature after removal from the furnace was two minutes.

In order to remove any contaminated surface layer each side of the slice was lapped (a minimum of 10 mils) until reproducible four point probe resistivity readings were obtained.

Figure 2 shows a plot of log σ_i/σ_{298} vs. Δ 1/T where σ_i is the room temperature conductivity of material quenched from any absolute temperature T_i, σ_{298} is the conductivity of material slow cooled to 298° K and $\Delta\ 1/T = 1/298 - 1/T_i$. It can be seen from the data of Fig. 2 that cool quenching samples in the ranges shown always produced material of lower conductivity than that of material slow cooled at 298°K. It should be noted that while the ratios of the conductivities are crystal dependent, the configuration of the curves is generally the same. The curves of Fig. 2 each show two segments; a nearly vertical and a nearly horizontal portion. Extrapolations of the high and low temperature portions of the curve intersect in the 700°C to 800°C range. This suggests that there are different annealing mechanisms at temperatures above and below this point. In view of this consideration it was decided to concentrate on the range below 800°C.

Within a crystal, shifts of resistivity were observed for particular quench temperatures. In some cases (as in Fig. 3, solid curve 1) the greatest shifts occurred at lower temperatures. In other cases there was little or no change with lower quench temperatures (Fig. 3, solid curve 2). While the slices of Fig. 3 are numbered sequentially in increments of 75 mils each from the seed to the melt end of the ingot, the resistivity shifts which were observed cannot be attributed to position within the crystal. This point will be discussed later.

The temperatures at which the shifts occur vary among crystals.

The stability of the resistivity values during the post diffusion processing of the material into devices was studied. This was done by subjecting the material to the following simulated device fabrication heating cycles:

a. Heating to 750°C in a nitrogen atmosphere and maintaining for 10 minutes.
b. Heating to 400°C and maintaining for 5 minutes.

The dotted curves of Fig. 3 show the resulting resistivities of the samples after the fabrication heating cycles. Comparison of the dotted and solid curves indicates the resistivity remains approximately constant during such heat treatments. This suggests that the major shifts of resistivity occur during the diffusion heating and cooling cycle.

In general the net concentration of electrons decreased after heating. Fig. 4 shows the change in resistivity along crystals after heating at 1300°C, slow cooling to 500°C and quenching to room temperature. The magnitude of this decrease is larger toward the seed end of the crystal.

It can now be seen that the resistivity resulting

from the heat treatment associated with the solid curves of Fig. 3 cannot be due to crystal position. Care was exercised to select material from that portion of the crystal which displayed a negative slope on a $\Delta \rho$ vs. distance plot similar to those of Fig. 4. If the variation of the resistivity is merely a reflection of crystal position, then the resistivity should be largest at the lower quench temperature and smallest at the higher temperature; that this does happen will be seen by referring to the solid curve 1. However, an explanation other than slice position must be found for the material represented by solid curve 2 since the material (slice 24) farthest from the seed displayed the greatest shift.

To study the bulk lifetime of material from these cool-quench experiments, rectangular bars (approximately 1.52 x 0.25 x 0.27 cm) were cut from the center area of each slice. Gold ohmic contacts were plated onto each end. The lifetime values were then determined by the photoconductive decay method[6].

All lifetime values presented here have been corrected for surface recombination.

While in all cases material which was cool-quenched suffered a degradation of lifetime from the pretreated value, materials which were quenched from certain temperatures degraded less than those quenched from other temperatures. Such resulting "lifetime peaks" can be observed occurring between 500 and 700°C in Fig. 5.

In addition, the magnitudes of the resulting lifetimes decreased with increasing distance from the seed. This result is indicated in Fig. 5 where curves 1 through 3 progress respectively from the seed to the melt end of the crystal. While the data presented here concerns only one crystal this was a general phenomena which occurred in all the crystals tested. It should be observed that the sample which displays the peak of curve 1 is accompanied by a resistivity of 180 ohm-cm. That the lifetime is not solely a reflection of this high resistivity is demonstrated by curves 2 and 3. In both of these cases accompanying resistivity values are 8 ohm-cm.

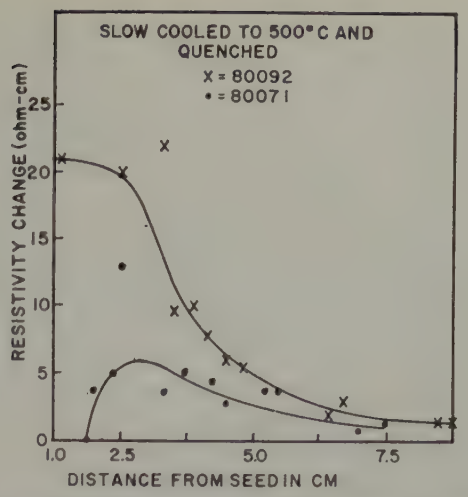

Fig. 4—Resistivity change along crystals after indicated heat treatment. All slices are numbered from the seed to the melt end. The original resistivity ranged from 5-10 ohm-cm.

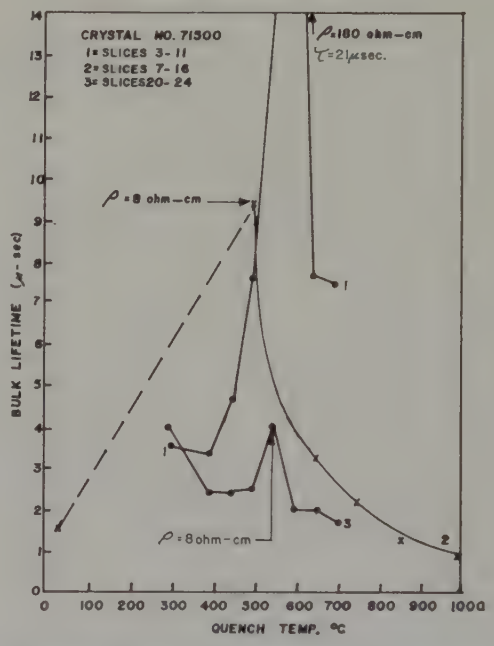

Fig. 5—Lifetime after "cool-quench" treatment. Pretreatment lifetimes were greater than 20 sec. for all samples. Bulk room temperature resistivities accompanying the *lifetime peaks* were 180, 8 and 8 ohm-cm for curves 1, 2, and 3 respectively.

Quench Anneal

For the "quench anneal" experiments, individual slices were cut in half. One-half of each slice was used for bulk studies, the other for device fabrication. Matching halves were subjected to the same heat treatment to allow the direct comparison of bulk properties and device characteristics from the same slice. Samples were heated at 1300°C for 20 hours as shown in Fig. 1. In the cooling cycle, some of the material was quenched to and held at a desired annealing temperature (Curve A) while the remainder was slow cooled to the annealing temperature (Curve B). Slices were quenched from annealing temperatures of 400°C, 600°C, and 700°C at selected times.

For purposes of evaluation all slices were lapped and processed as previously described.

In Fig. 6 we see typical resistivity and lifetime results for the above-mentioned annealing temperatures. Results of other crystals receiving the same heat treatment differ only in magnitude of resistivity and the time to reach equilibrium. As indicated in Fig. 6, the curve to the left of points A, B, and C represents the "quench anneal" path (Fig. 1, curve A). The area to the right represents the slow cool and anneal path (constant temperature portion of Fig. 1, curve B).

By heating at 1300°C and quenching to 400°C the electron concentration is decreased from its original

value. This decrease continues for the first 30 minutes of annealing. After this time there is a rapid increase in the concentration to an equilibrium value. Exact times necessary for the material to establish an equilibrium condition are crystal dependent. This is due to considerations which have not been explored in this article (e.g. oxygen content, dislocation densities, crystal growing variables, etc.). However, in all crystals which have been investigated a cooling rate of 115°C/hr. was adequate to obtain equilibrium. It is noted some crystals can be cooled at a faster rate. This is indicated by the 600°C and 400°C curves of Fig. 6. For example, a rate of 550°C/hr. would have been adequate for the 600°C curve.

The net result after achieving equilibrium is a decrease in the electron concentration from the original concentration of 6×10^{14} cm^{-3}. Considering the juncture of the 400°C "quench anneal" and the "slow cool" curves at $t = 9.0$ hours (point C), it is found that the magnitude and behavior of the electron concentration is the same for either cooling path. Hence, the same resistivity (electron concentration) results are obtained by either slow cooling the material from 1300°C at 100°C/hr. to 400°C and then quenching to room temperature, or by initially quenching from 1300°C to 400°C and annealing at 400°C for 9 hours before dropping to room temperature.

The lifetime of this material does not seem to be improved by these particular heat treatments. The lack of lifetime improvement for the slow cooled samples quenched at 600 and 700°C is probably due to crystal position as previously discussed.

In subjecting these samples to device fabrication heating, the shape of the curve remained the same. Depending upon the particular crystal, the ultimate electron concentration would remain reasonably stable or decrease slightly, (the maximum decrease being a factor of two). Lifetime values remained reasonably stable or improved slightly.

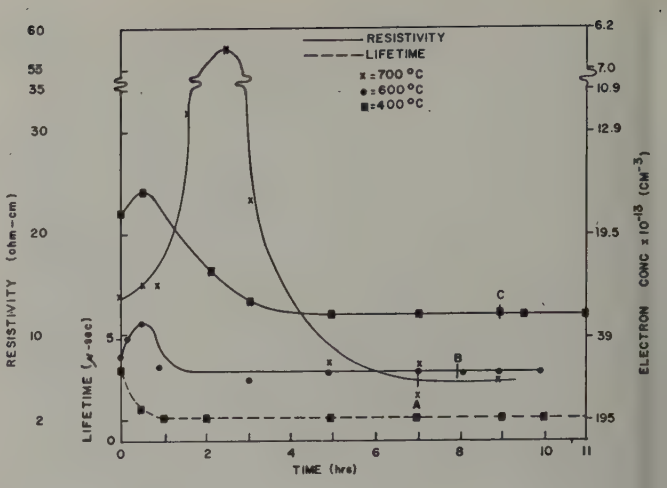

Fig. 6—Resistivity vs. time. The points A, B, and C represent the junctures of the "slow-cool" and the "quench anneal" cycles, the "quench anneal" portion being to the left of the points.

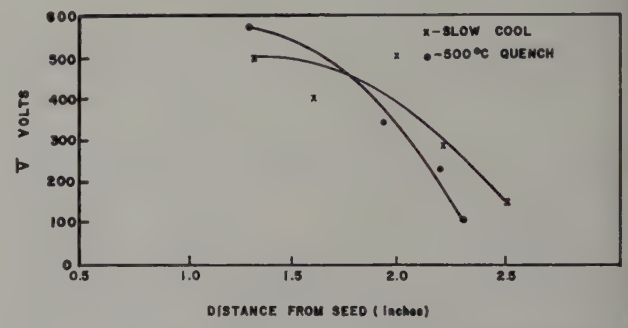

Fig. 7—Junction breakdown voltage. Distributions vs. distance from the seed.

Summary

To summarize we find:

1. The magnitude of the electron concentration decrease and the shift in lifetime after heating is dependent both upon the slice position in the crystal and the crystal itself.
2. The final electron concentration is dependent upon the particular quench temperature.
3. Maximum lifetimes were obtained in quenching between 500°C and 600°C.
4. When material was quenched from 1300°C to a particular annealing temperature and held at this temperature for an appropriate time, the resulting material and its devices were identical with that which was slow cooled from 1300°C to the same temperature.

Device Application

To orient the results of this article with p-n junction characteristics, a test device was fabricated. This device consisted of a 90 mil diameter chip with p-n junction penetration of 4 mils. These devices were assembled and etched in a mixture of hydrofluoric, nitric, and acetic acids; rinsed in deionized water; and nitrogen dried before testing. All units were tested in a dry N_2 atmosphere. Although the possibility of surface limitation exists, precautions were taken to minimize this effect.

Based upon the resistivity and lifetime results presented herein, certain device conclusions can be made. Several of these are discussed below.

The curves of Fig. 2 suggest that further slow cooling after attaining a temperature of 500°C result only in minimal changes of resistivity. From this it would be predicted that devices produced either from silicon quenched from 500°C or silicon which had been slow cooled to room temperature would have the same electrical characteristics (i.e. device p.i.v.'s). Devices made of material which had been slow cooled from 1300°C to room temperature and of material which had been slow cooled from 1300°C to 500°C and then quenched to room temperature are compared in Fig. 7. It is seen that either process gives essentially the same result. This behavior was typical of all crystals tested (a total of twelve).

As previously discussed, the resistivity change upon heat treatment is greatest at the seed end of the crystal, (Fig. 4). This results in significantly higher p.i.v. distributions, (Fig. 7), in devices made from seed end material.

In the "quench anneal" studies it was shown that material quenched from the diffusing temperature (i.e. 1300°C) to some intermediate temperature (e.g. 600°C) and annealed at this temperature for a period of time produces the same resistivity and lifetime results as slow cooling (i.e., approximately 100°/hr.) to the same temperature (e.g. 600°C) and quenching to room temperature. Reference to Fig. 6 will show that the required time for the quench and anneal process can be materially less than that of the slow cool process. In the case of the 600°C example the quench and anneal process would take approximately two and a half hours while the slow cool process would consume eight hours.

For devices requiring the highest possible lifetime, the material should be selected from the seed end of the crystal and quenched between 500 and 700°C as indicated in the previous discussion of Fig. 5. It should be noted that the quench anneal path (Fig. 6) does not enhance the bulk lifetime.

Acknowledgements

The authors are grateful to Messrs. J. Courier, V. Barry, and R. Sweeney for their contributions to the experimental work and to Drs. W. Waring, B. Selikson, and W. D. Straub for their helpful discussions.

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A Monostable Transistor Circuit For High-Ratio Frequency Division And Generation Of Short Pulses

Part 2.

WERNER STEIGER

(Continued from p. 35, Aug. 1961)

From Equations (22), (25) and (32a to c), the following functions relating the regeneration time τ_r to the transistor and circuit parameters can now be obtained. Putting

$$\left.\begin{aligned} x &= \tau_r/T_r \\ \xi &= \frac{T_{CV1}\,T_{CV2}}{\mu_{12}\,\mu_{21}\,T_r^2} \\ \eta &= 1 - \frac{b_1+b_2}{2} = 1-b \end{aligned}\right\} \qquad (33)$$

we have for case (a):

$$(1-b_2)\,e^{(1-b_1)x} - (1-b_1)\,e^{(1-b_2)x} = (b_2-b_1)\,[\xi\,(1-b_1)\,(1-b_2) - 1]\,, \qquad (34a)$$

For case (b):

$$(\eta x - 1)\,\exp\,(\eta x) = \xi\eta^2 - 1, \qquad (34b)$$

For case (c):

$$x = \sqrt{2\,\xi}, \quad \text{i.e.} \quad \tau_r = \sqrt{2\,\frac{T_{CV1}\,T_{CV2}}{\mu_{12}\,\mu_{21}}}. \qquad (34c)$$

One would like to have τ_r (or x) as an explicit function of all the parameters. But since, except in case (c), the relations are transcendental, τ_r can at best be presented graphically. In Fig. 8, ξ has been calculated for case (b) as a function of x with η as parameter. Case (c) fills the gap where Eq. (34b) fails, namely for $\eta = 0$. More difficult is case (a), where x is a transcendental function of three variables. Eq. (34a) can be approximated by a series ex-

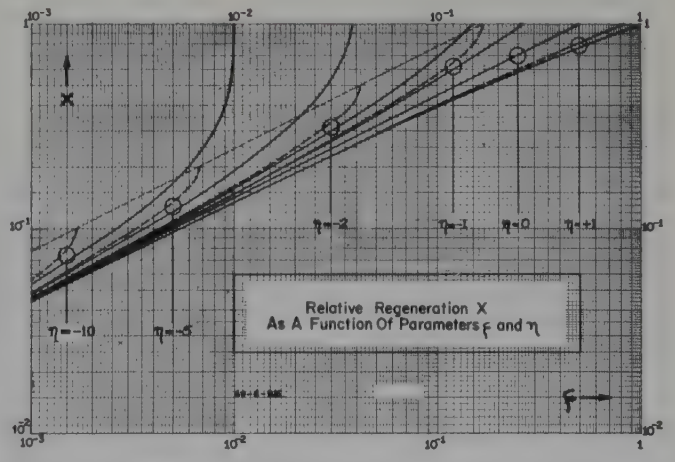

Fig. 8—Relative regeneration time, x, as a function of parameters ξ and η.

pansion. The terms beyond third order neglected, this yields

$$\eta \frac{x^3}{3} + \frac{x^2}{2} \simeq \xi, \tag{35a}$$

which is also shown in Fig. 8 (dashed curves). These curves, however, have a vertical tangent at $x = -1/\eta = \sqrt{6\,\xi}$. Beyond this value they turn back to the left where they are obviously worthless in our case.

As long as the two transistors are not too different, Eq. (34b) is preferable to Eq. (35a) for approximation of the general case.

Current-gain Dependence of the Timing

1 Delay Time

From Equation (17) is seen that, with the approximations that led to Eq. (17) the gain dependence of τ_d is

$$\frac{\delta\tau_d}{\delta\alpha_2} \simeq \frac{1}{2} CR_3 (R+R_1)(G+G_2). \tag{36}$$

2 Regeneration Time

The gain dependence of τ_r is here investigated for identical transistors Q_1 and Q_2 (except polarity) and constant collector time constants T_{CV}. Since

$$T_{CV} \simeq (1-\alpha)\, T_{BV}, \tag{37}$$

it follows from Eq. (34b) that

$$\frac{\delta x}{\delta\alpha} = \frac{T_r}{\eta x\, T_{CV}} (2\,\xi\, e^{-\eta x} - x^2). \tag{38}$$

This derivative can only be expressed without the dependent variable x if $\eta = 0$ $(x = \sqrt{2\,\xi})$:

$$\left.\frac{\delta\tau_r}{\delta\alpha}\right|_{\eta=0} = -\frac{2T_{CV}}{3\,\mu_{12}\mu_{21}}. \tag{39}$$

But as $\eta = 0$ is right in the range of interest, this result will still be useful and can be employed in the vicinity of $\eta = 0$.

3 Compensation

Comparison of Eq. (36) and (39) reveals that the two gain dependences are of opposite sign. Therefore, a compensation is possible by proper choice of R_3.

Note that α_2 in Eq. (36) and α in Eq. (39) may be different because α_2 is the value when Q_2 is almost fully conducting, while α applies to the low current level where regeneration starts (typically one tenth

TABLE III—Measurements and Calculations

Transistors	Conditions	SXG 8 Q_1 — NPN #1	SXG 8 Q_1 — NPN #3	SXG 7 Q_2 — PNP #2	SXG 7 Q_2 — PNP #4	
f_T	6 V	160	200	190	220	mc
β	6 ma	37	84	25	100	—
$\delta\alpha_2/\delta T$	50°C			10^{-4}	2.10^{-5}	$\deg^{-1}$
T_{CV}	$\Delta V_C = 1.5$ V	17	14	15	14	ns
T_{BV}	$\Delta I_C = 1.5$ ma	420	660	220	840	ns
β_{reg}		25	47	15	60	—
Transistors		1 + 2	3 + 4	1 + 2	3 + 4	
C		100	100	220	470	pF
C_2		22	22	47	100	pF
τ_d	meas.	1090	1120	2250	4940	ns
	calc.	1120	1170	2340	5100	ns
τ_r	meas.	140	110	200	260	ns
	calc.	175	155	200	180	ns
$(\tau_d + \tau_r)$	meas.	1230	1230			ns
$\Delta(\tau_d + \tau_r)$	meas./calc.	5	7	3.5	1.5	%
$\delta\tau_d/\delta E$	meas.	−8	−6	−15	−30	ns/v
	calc.	−8.2	−8.2	−17	−36	ns/v
$\delta\tau_r/\delta E$	meas.	−12	−8	−20	−20	ns/v
$\delta\tau_d/\delta T$	meas.	−0.3	−0.9	−0.8	−2.4	ns/°C
	calc.	−0.22	−0.33	−0.45	−1.4	ns/°C
$\delta\tau_r/\delta T$	meas.	−0.4	−0.12	−0.4	−0.4	ns/°C

or even less of the "on"-current). Since

$$\delta\alpha/\delta\alpha_2 \simeq \beta_{2\ on}/\beta_{\ reg}, \qquad (40)$$

The sum of the variations given by Eq. (36) and (39) should be zero if

$$R_3 \simeq \frac{4\ T_{CV}\ (\beta_{2\ on}/\beta_{\ reg})}{3\ \mu_{12}\mu_{21}\ C\ (R+R_1)\ (G+G_2)} \qquad (41)$$

When using this equation it should be kept in mind that it has been derived under various simplifications (including $\eta = 0$). However, it does show that a compensation is possible, which, by the way, is influenced by the transistor speed. The slower the transistors, or the shorter the timing period, the larger is the necessary compensating resistor. These points have been verified experimentally. For the circuit in Fig. I, with the transistors specified in the section on "Measurements", expression (41) yields approximately 1300 ohms. The experimentally determined value was about 2000 ohms, resulting in timing completely independent of current gain.

Measurements

Measurements under various conditions are listed in Table III together with the calculated values. The circuit has been investigated with a pair of low gain and a pair of high gain transistors. The timing capacitor C was given several values, while resistance R was chosen 15000 ohms ($\pm 5\%$ components). The base and collector time constants T_{BV} and T_{CV} were measured according to Beaufoy and Sparkes[2]. The transistors were switched from cutoff to approximately the level where regeneration starts in the monostable circuit. β_{reg} is the ratio of T_{BV} and T_{CV}.

The results show that the circuit performance can be made quite independent of transistor gain. The measured timing ($\tau_d + \tau_r$) was practically within component tolerances of the calculated values. The variations of timing with supply voltage (at 12 volts) ranged from -1% per volt to -1.7% per volt, the better values for the high gain transistors. The changes of timing with temperature were measured with R and C outside the oven. They were somewhat higher than calculated and typically in the vicinity of -0.05% per °C at 50°C. An exception were the high gain units in the circuit for short timing ($C = 100_{pF}$), exhibiting almost twice this rate. For the reason discussed in section "Circuit Description," this seems to indicate that Q_2, due to its very high gain, slightly entered saturation.

Figures 9 to 12 show the waveforms produced by the divider under various conditions. Each figure contains the input signal, output at collector of Q_1 and output at collector Q_2. ■■

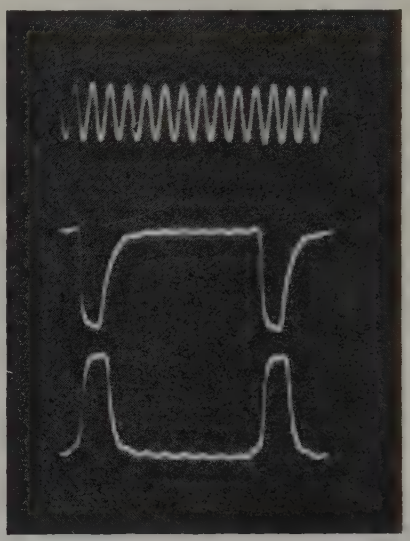

Fig. 9—10 megacycles divided by 10; C = 100pF, R ≃ 10KΩ.

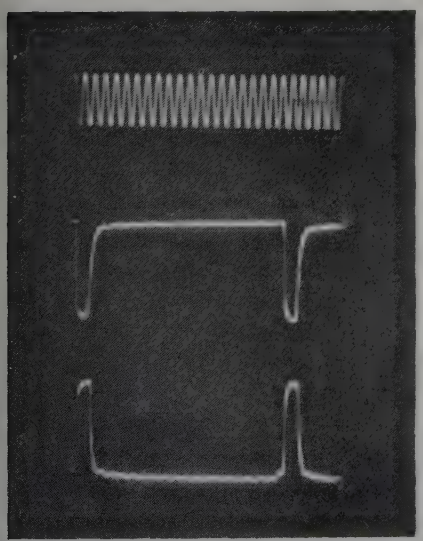

Fig. 10—6 megacycles divided by 20; C = 220pF, R ≃ 20KΩ.

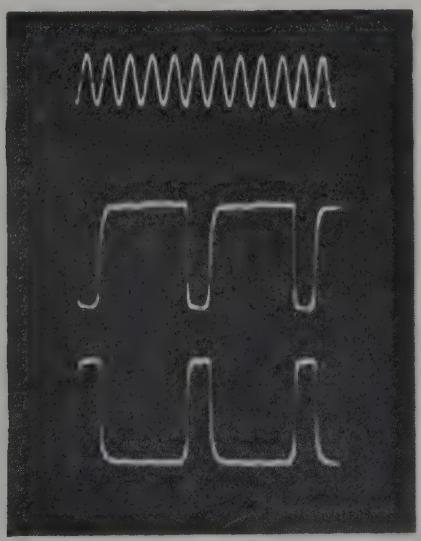

Fig. 11—2.5 megacycles divided by 5; C = 100pF, R ≃ 20KΩ.

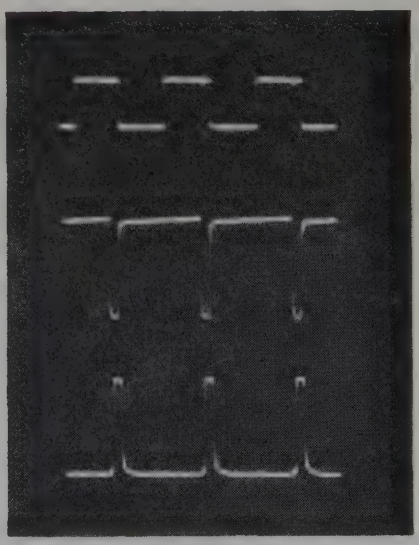

Fig. 12—Short pulses from 125kc sq. wave; C = 470 pF, R ≃ 20KΩ.

A Slide Calculator For Determination of Transistor Dissipation

JERRY EIMBINDER*

PERMISSIBLE TRANSISTOR DISSIPATION or the maximum junction temperature rise for a transistor in continuous or switching service may be readily determined by the use of an easily constructed slide calculator. This article discusses the construction and operation of such a calculator, as well as examples of its use in free-air and heat-sink applications.

D-C vs. Intermittent Service

Technical bulletins issued by transistor manufacturers generally provide dissipation ratings based on continuous steady-state service. However, for intermittent service, the published maximum ratings may usually be exceeded without damage to the transistor. For example, in many switching, pulse, or computer applications the highest permissible dissipation is often several times the published continuous-service, or direct-current value, as shown by the chart in Table I.

Table I—Maximum Transistor Dissipations for Type 2N404.

Type of Service	Maximum Allowable Transistor Dissipation-milliwatts	
	At 25°C	At 55°C
Continuous D-C Operation	120	35
Typical Intermittent Application	1420	720

Construction of Calculator

The *Transistor Dissipation Calculator* shown in Figs. 1, 2, 3, and 4 (see pp. 36, 37) may be used to determine the higher dissipation values permissible for intermittent service.

This device can be assembled in four easy steps, as follows (1) Cut along the lines indicated, (2) Cut out the windows, (3) Staple the front and rear views together at the X marks, (4) Paste the front and rear views of the slide together and insert. For increased stability, all parts should be mounted on thin cardboard before assembly, and the front and back sections should be separated with cardboard strips along the dotted lines at the top and bottom of the calculator.

The symbols referred to on the calculator, in the Table of Constants (Table II), and elsewhere in this article are defined as follows:

d = duty cycle

$$K = \frac{\Delta T_{j\ max}}{P_{max} R_T}$$

P_{max} = maximum permissible transistor dissipation
R_T = total thermal resistance
R_1 = maximum thermal resistance, collector junction to case
R_2 = chassis thermal resistance
R_3 = insulation-and-contact thermal resistance
T_a = ambient temperature
$\Delta T_{j\ max} = T_{j\ max} - T_a$
$T_{j\ max}$ = maximum junction temperature
t_0 = pulse duration
τ_1 = thermal time constant

Use of Calculator

In order to use the calculator it is necessary to know the maximum junction-temperature rating of the transistor and the values of two constants: the thermal-time constant of the transistor and the thermal-resistance constant for both the transistor and a heat-sink arrangement (if one is used). This information is usually provided by manufacturers' specification sheets. Table II lists such data for some typical germanium and silicon transistors. For free-air applications (applications not requiring the use of a heat sink), the information given in the Table of Constants is sufficient for obtaining P_{max}.

In pulse and switching applications, the maximum permissible transistor dissipation (P_{max}) varies with pulse duration (t_o), duty cycle (d), and ambient temperature (T_a). If the constant values and the values of t_o, d, and T_a are known for a given application, the calculator may be used to determine P_{max}.

In general, for free-air applications, P_{max} may be calculated as follows: (1) Set t_o/τ_1 at arrow. (2) Read K opposite correct duty-cycle curve. (3) Set K at $\Delta T_{j\ max}$. (4) Read P_{max} at R_T.

The calculator may also be used to calculate P_{max} for heat-sink applications. The procedure is the same as above except for the computation of R_T. R_1 is determined from the Table of Constants. R_2 is determined from the calculator by setting the area for a single side of the heat sink (chassis) under the arrow

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Table II—Table of Constants

Type	Maximum Junction Temp. $T_{J_{MAX}}$ °C	Thermal Time Constant τ_1 Millisec.	Thermal Resistance (free air) R_T °C/watt	Thermal Resistance (junction-to case) R_1 °C/watt
Germanium Transistors				
2N109	85	12	800	—
2N139	85	10	750	—
2N140	85	10	750	—
2N217	85	12	800	—
2N218	85	10	750	—
2N219	85	10	750	—
2N247	85	12	750	—
2N269	85	10	500	—
2N270	85	12	320	—
2N274	85	10	620	—
2N301	91	5	—	2
2N301-A	91	5	—	2
2N384	85	10	620	—
2N398	85	12	750	—
2N404	85	10	500	—
2N456	100	8	—	1.4
2N457	100	8	—	1.4
2N561	100	8	—	1.5
2N578	85	15	500	—
2N579	85	15	500	—
2N580	85	15	500	—
2N581	85	10	500	—
2N582	85	10	500	—
2N583	85	10	500	—
2N584	85	10	500	—
2N585	85	12	500	—
2N586	85	12	240	—
2N643	85	10	500	—
2N644	85	10	500	—
2N645	85	10	500	—
2N1014	100	8	—	1.5
2N1023	85	10	620	—
2N1066	85	10	620	—
2N1090	85	12	500	—
2N1091	85	12	500	—
2N1183	100	8	75	—
2N1183-A	100	8	75	—
2N1183-B	100	8	75	—
2N1184	100	8	75	—
2N1184-A	100	8	75	—
2N1184-B	100	8	75	—
2N1224	85	10	620	—
2N1225	85	10	620	—
2N1226	85	10	620	—
2N1300	85	10	400	—
2N1301	85	10	400	—
2N1384	85	14	250	—
2N1395	85	10	620	—
2N1396	85	10	620	—
2N1397	85	10	620	—
Silicon Transistors				
2N1479	175	10	200	37.5
2N1480	175	10	200	37.5
2N1481	175	10	200	37.5
2N1482	175	10	200	37.5
2N1483	175	10	100	10
2N1484	175	10	100	10
2N1485	175	10	100	10
2N1486	175	10	100	10
2N1487	175	12	—	2.5
2N1488	175	12	—	2.5
2N1489	175	12	—	2.5
2N1490	175	12	—	2.5
2N1511	175	12	—	2.5
2N1512	175	12	—	2.5
2N1513	175	12	—	2.5
2N1514	175	12	—	2.5

at "A." R_2 is read in °C/watt at window "B," "C," "D," and "E" depending on thickness of material, type of material, and mounting position. R_3 is determined from Table III. R_T then equals $R_1 + R_2 + R_3$.

If the transistor dissipation is known, the calculator can also be used to determine the maximum rise in junction temperature for a transistor.

Table III—Table of Insulation-and-Contact Thermal Resistances (R_3)

Insulator	Thickness Inches	R_3 °C/watt
No Insulator	—	0.4
Anodized Aluminum	0.016	0.4
Anodized Aluminum	0.125	0.5
Mica	0.002	0.5
Mica	0.004	0.65
Mylar	0.003	1
Glass Cloth (Teflon coated)	0.003	1.25

Highly-conductive silicone lubricant applied between mating surfaces.
Values of R_3 vary according to manufacturer.

Example One: Determining P_{max} For A Free-Air Intermittent Application

Problem: Determine P_{max} for the 2N404 in a computer application having the following requirements: $d = 0.01$, $t_o = 10$ microseconds (10^{-5} second) and $T_a = 25°C$.

Solution: From the table of constants: $\tau_1 = 10$ milliseconds (10^{-2} second), $T_{j\,max} = 85°C$, and $R_T = 500°C/watt$.

$t_0/\tau_1 = 10^{-5}/10^{-2} = 10^{-3}$

$\Delta T_{j\,max} = T_{j\,max} - T_a = 85\text{-}25 = 60°C$

Follow the procedure given on the front of the calculator:

1. Set t_0/τ_1 at 10^{-3}
2. Read $K = 8.5 \times 10^{-2}$
3. Set this value of K at $\Delta T_{j\,max} = 60°C$
4. Read $P_{max} = 1.42$ watts (1420 milliwatts) at $R_T = 500°C/watt$

Example Two: Determining P_{max} For A Heat-Sink Intermittent Application

Problem: Determine P_{max} for the 2N1485 in a power-switching application having the following requirements: $d = 0.01$, $t_o = 1$ millisecond (10^{-3} second), and $T_a = 125°C$. The transistor is vertically mounted on a square copper heat sink having a thickness of $\frac{3}{16}$ inch and an area (or a single side) of 50 square inches. A 0.016-inch anodized aluminum washer is used between transistor and chassis surfaces.

Solution: From the table of constants, $\tau_1 = 10$ milliseconds (10^{-2} second), $T_{j\,max} = 175°C$, and $R_1 = 10°C/watt$.

$t_0/\tau_1 = 10^{-3}/10^{-2} = 10^{-1}$

$\Delta T_{j\,max} = T_{j\,max} - T_a = 175\text{-}125 = 50°C$

$R_2 = 1.1$ °C/watt, $R_3 = 0.4$ °C/watt (from rear side of calculator)

$R_T = R_1+R_2+R_3 = 10+1.1+0.4 = 11.5$ °C/watt

Follow the procedure given on the front of the calculator:

1. Set t_0/τ_1 at 10^{-1}
2. Read $K = 2.4\times10^{-1}$
3. Set this value of K at $\Delta T_{j\,max} = 50°C$
4. Read $P_{max} = 18$ watts at $R_T = 11.5$ °C/watt

Example Three: Determining P_{max} For A Heat-Sink Continuous Application

Problem: Determine P_{max} for the 2N1485 for the same conditions encountered in Example Two, but with the transistor continuously operated in the "on" condition.

Solution: For continuous-service applications, steps 1 and 2 are omitted.

3. Set $K = 10°$ ($K = 10°$ for all continuous-service applications) at $\Delta T_{j\,max} = 50°C$.
4. Read $P_{max} = 4.8$ watts at $R_T = 11.5$ °C/watt

Example Four: Determining $\Delta T_{j\,max}$ For A Free-Air Intermittent Application

Problem: Determine the maximum rise in junction temperature for the 2N586 in a switching application having the following requirements: $d = 0.25$, $t_0 = 6$ milliseconds (6×10^{-3} second), $T_a = 25°C$, and transistor dissipation = 105 milliwatts.

Solution: From the table of constants, $\tau_1 = 12$ milliseconds (1.2×10^{-2} second), $T_{j\,max} = 85°C$, and $R_T = 240$ °C/watt.

$t_0/\tau_1 = 6\times10^{-3}/1.2\times10^{-2} = 5\times10^{-1}$

Proceed as follows:

1. Set t_0/τ_1 at 5×10^{-1}
2. Read $K = 6\times10^{-1}$
3. Set the transistor dissipation of 105 milliwatts at $R_T = 240$ °C/watt
4. Read $\Delta T_{j\,max} = 15$ at $K = 6\times10^{-1}$

In this application the maximum junction temperature will be 40°C ($T_j = T_a + \Delta T_{j\,max} = 25+15 = 40°C$)

Conclusion

The calculator is intended as a guide for circuit designers. Design engineers are reminded to review the published technical data for the transistor under consideration to ensure that maximum voltage, maximum current, and other maximum ratings are not exceeded. In applications where thermal stability or thermal runaway is a consideration, particularly for values of $\Delta T_{j\,max}$ less than 10°C, the normal precaution of designing with the adequate circuit-stability factor for the corresponding collector voltage and power dissipation should be observed.

Acknowledgment

The author wishes to express appreciation to Mr. Carl R. Turner for his assistance in the preparation of this article.

Semiconductor Producers Are the "Mr. Clean" of the Industry

William C. Diman*

FURNACES AND EQUIPMENT used in the semiconductor field include alloying and soldering furnaces, diffusion furnaces, crystal growing and zone leveling furnaces and all the equipment used in assembling semiconductors and producing glass-to-metal seals. Equipment ranges all the way from simple manual furnaces to fully automated and "exotic" units such as vacuum conveyor furnaces. The most important consideration in any of this type of work is maintaining a clean product from start to finish. Contamination of any kind, other than the controlled contamination applied during the diffusion process, will decrease the expected yield of acceptable product. Therefore, the semiconductor industry is interested in three prime requisites: pure dry atmospheres (again, other than the controlled contaminants); extremely sensitive and uniform temperature control; and one of the most important features — reproducibility.

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Once a particular time/temperature profile is attained in a furnace, the user will want to maintain this profile during the complete process. Should it be altered in any way to suit some other type of work, he will want to be able to return to the same settings on the instrumentation supplied with the furnace to reproduce the original time/temperature profile in the shortest period of time.

Any variable that can be kept out of the production picture means increased yield in production, plus simpler trouble-shooting techniques when a problem does arise. If the producer of semiconductor products knows that a particular time/temperature profile and atmosphere combination will produce high yields of quality work, and if trouble should develop, he will be able to spot the difference or the variable that is causing the trouble without expensive shutdown time or loss of production.

Alloying Furnaces

Alloying and soldering furnaces, extensively used in the semiconductor industry, are basically either the straight-through conveyor type or the inclined conveyor type. Both types produce excellent results. As minute quantities of oxygen, trapped in the links, will be carried in on any belt-conveyor system, this oxide (or oxygen source) must be flushed away from the work and out of the furnace prior to the work reaching the temperature at which oxygen could become a detrimental factor. On the straight-through furnace, the contaminant (oxygen) is generally flushed from the furnace through a unique arrangement of nitrogen curtains and controlled atmosphere flow baffles.

In the case of the inclined furnace, the baffles and nitrogen curtains are not required, as the atmosphere is pumped into the furnace at the top of the inclines and the atmosphere flowing down against the oncoming work tends to set up a reverse flushing action that carries the contaminants down and out of the furnace prior to the work reaching a temperature point where these contaminants would become detrimental and decrease the yield.

The advantages of the straight-through furnace are obvious as the furnace fits into the standard production setup with personnel loading the belt while sitting at a loading table that is part of the furnace. In the case of the inclined furnace, a separate mechanized loading table has to be applied to carry the work from the horizontal loading position on the table to the inclined loading section.

The temperature control within these furnaces is extremely close, as a result of employing saturable core reactor setups or other electronic systems which hold temperature uniformity to close tolerances (in the vicinity of $\pm\frac{1}{2}$ °C).

The furnaces supplied to the semiconductor industry are usually supplied as complete packages and, in many cases, are pretested prior to shipment to guarantee ability to maintain the necessary time/temperature profile.

The belt conveyor mechanism is usually of the electronic drive type to eliminate variables that could creep into the picture through changes in drive speed.

Diffusion Furnaces

Diffusion furnaces for both silicon and germanium have the same stringent requirements. When talking diffusion furnaces, the first question asked by any potential equipment buyer is "How much flat zone can you guarantee, and what uniformity will you get?"

For the majority of furnaces on the market it is possible to achieve uniform flat zones in the order of 8" although the available range for different manufacturers may be from 2" to 24". Flat zones are generally controllable to ± 1 °C. The average user of diffusion furnaces, although looking for the theoretical ±0 °C flat zone, has more or less standardized on ±2 °C.

Diffusion furnaces are generally constructed to handle either gaseous diffusion or applied source diffusion. In gaseous diffusion, controlled contaminants are carried into the heating chambers by means of a carrier gas and deposited on the wafer. In applied source diffusion, the wafers are first treated, dipped or doped with a contaminant and then placed into the furnace. Applied source diffusion obviously does not require a source chamber to carry controlled contaminants into the heating chamber as the contamination is already on the piece.

Diffusion furnaces are sold (1) as high temperature units for silicon wafers, (2) as low temperature units for germanium wafers, or (3) as units equipped with both high heat chamber and source chamber. Germanium wafers are usually treated by employing a source and high heat chamber with the high heat chamber being used at a maximum of 1000 °C. On the silicon work, the gaseous diffusion furnace has the source and high heat chamber with the high heat being used at 1285 °C to 1300 °C. In the case of applied source diffusion, of course, only one chamber is used in both the high and low temperature processes. Applied source diffusion furnaces are available as completely automatic units where finished wafers will be ejected from the furnace every hour as compared to the usual heat-up, soak, and cool-down of the programed batch processes which may take up to 20 hours per batch.

Crystal Growing and Zone Leveling

Prior to actually treating the wafer or assembling and alloying the transistor unit, the initial crystal has to be grown and refined. The growing of a crystal may be done either horizontally or vertically with two schools of thought on which is the better approach. The refining refers to controlled melting of a portion of a crystal to localize contaminants for easy removal. Here again, temperature is the critical objective and the moving of the heat source in a smooth, steady motion is required.

Dry Boxes

As cleanliness is first and foremost when it comes to handling any semiconductor material, dry boxes are employed wherever practical to keep the work within a dry atmosphere. This dry atmosphere can vary from dry air to dry nitrogen. Again, this is up to the particular customer's requirements and the economics of the case.

Dry boxes should be fitted with equipment capable of taking moisture out of the source gas. Such dryers should be compact, capable of handling either air or nitrogen or other gas. They should be fully automatic.

There are a number of different dryers on the market. The majority consist essentially of a round cylinder loaded with a desiccant, and have some sort of heat source to apply to the desiccant for driving off absorbed moisture. Although all commercial dryers are capable of drying air or nitrogen, they do not necessarily take out the moisture down to the extremely low dewpoints that a dryer designed for dry box applications can accomplish. It is essential that the heater designed for boiling out the moisture be very well thawed out; otherwise, there may be minute quantities of moisture that will remain in the desiccant.

When the semiconductor manufacturer selects a dryer, he should make certain that the unit will remove moisture to the requisite dewpoint and continue to reproduce this same dryness hour after hour, and day after day.

Nitrogen

Nitrogen, either as straight nitrogen or combined with hydrogen as a "forming gas," is used extensively in semiconductor production. The quantity of nitrogen used over the course of a year is quite considerable. In three or four test cases, by replacing a bottled or bulk gas system with a nitrogen generator which produces nitrogen from cracked gas and air through the necessary scrubbing towers and dryers, the user was able to save in the order of $150,000.00 in 36 to 48 months. Nitrogen generators can be efficient to the point where they will produce gas more than adequate in purity for semiconductor processes.

Glass-To-Metal Sealing

A branch of industry closely related to the semiconductor industry deals with the initial glass-to-metal seal or the ceramic-to-metal seal employed in many of its components. There are three operations involved in glass-to-metal sealing: outgassing, oxidizing, and sealing.

The nitrogen generator may be of considerable advantage here again, because (1) in making the final glass-to-metal seal, nitrogen is an ideal protective atmosphere, and (2) due to the volumes of gas involved to protect work in a straight-through conveyor furnace, an on-the-spot nitrogen generator soon pays for itself in reduction of gas costs.

APPLICATIONS ENGINEERING DIGESTS

APPLICATIONS ENGINEERING DIGEST NO. 71

(Circle 198 on Reader Service Card)

Hole Storage Measurement for Types 2N1122 and 2N1122A Transistors; Sprague Electric Co., North Adams, Mass.

The hole storage factor, K_s', is a measure of the charge stored in the base region of the transistor per unit excess base current. The measurement is performed by operating the transistor with zero collector current at preset emitter current. The emitter is then opened with a diode and the charge which was stored in the base region is caused to charge a condenser connected in the collector circuit. A measurement of the voltage on this condenser gives a measurement of the charge which was stored in the base. See *Fig. 71.1.*

Although the units for the hole storage factor are seconds, this factor is not a time measurement and does not imply that the storage time in any particular circuit is that specified. The hole storage time in an actual circuit may be derived from the following formula:

$$t_s = K_s' \ln\left(1 + \frac{I_{BX}}{I_{BS} - I_{B2}}\right),$$

where I_{BS} is the base current just required to saturate the transistor in the particular circuit being used, I_{BX} is the excess base current, and I_{B2} is the base current during the interval during which the transistor is being brought out of saturation. If I_{B2} is reverse current then the sign is negative. If the saturated collector current is I_{C1}, I_{BS} is calculable from

$$I_{BS} = \frac{I_{C1}}{\beta_o}$$

where β_o is the d-c current gain of the transistor at the edge of saturation. The excess base current is given by

$$I_{BX} = I_{B1} - I_{BS}$$

where I_{B1} is the base current before the initiation of turn off.

The absolute value of C_1 is 500 $\mu\mu f$. The capacitance of C_1 is adjusted using the test fixture shown in *Fig. 71.2* so that the peak voltage across C_1 is 0.3 volts.

The value of K_s' in nanoseconds can be calculated using the formula:

$$K_s' = \frac{V_s'\, C_1}{I_b}$$

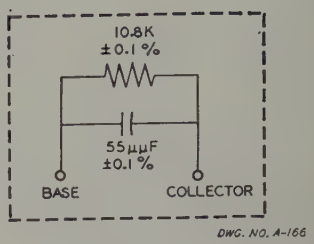

Fig. 71.2—Test fixture.

where

I_b is in milliamperes
V_s' is in volts
C_1 is 500 $\mu\mu f$

For example: $K_s' = 100$ nsec when $V_s' = 0.2$ volts.

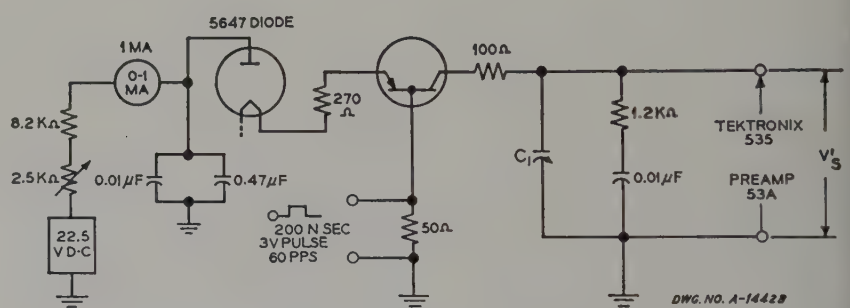

Fig. 71.1—Circuit for hole storage measurement.

APPLICATIONS ENGINEERING DIGEST NO. 72

(Circle 199 on Reader Service Card)

Chopper Transistors; Sperry Semiconductor Div., South Norwalk, Conn.

A transistor chopper in the normal connection with its approximate equivalent circuit is shown in *Fig. 72.1.* It consists of a perfect switch in series with the offset voltage source V_p and the dynamic resistance r, all shunted by the offset current generator I_p.

The output voltage from this circuit with the transistor conducting will be the offset voltage V_p, plus the IR drop across the dynamic resistance r.

$$V_{\text{out on}} = V_p + \frac{v_{in} \cdot r}{R_L + r} \qquad (1)$$

When the transistor is cut off, the output voltage is the input voltage v_{in} minus the voltage drop produced by the offset current through the load resistor.

$$V_{\text{out off}} = v_{in} - I_{PN}R_L \qquad (2)$$

These two equations show that in low level choppers the amplitude of the minimum input signal is limited by the offset voltage, the offset current, and, to some extent, also by the dynamic resistance of the transistor.

Offset Voltage

The offset voltage is the potential appearing between the collector and emitter terminals when the transistor is operated in the saturation region. This voltage is primarily a function of the transistor forward current transistor ratio (β), operating temperature, and the IR drops in the collector and emitter regions. Neglecting the usually low alloy transistor collector and emitter spreading resistances, an approximate equation of the offset voltage of a transistor operated in the normal common emitter configuration can be written in the following form.

$$V_{PN} = -\frac{kT}{q} \ln \frac{1}{\alpha_I} = -\frac{kT}{q} \ln\left(1 + \frac{1}{\beta_I}\right) \qquad (3)$$

where α_I is the forward current transfer ratio measured near the saturation region with the emitter operating as a collector and collector as an emitter in the common base configuration (inverse alpha), β_I inverse beta near the satura-

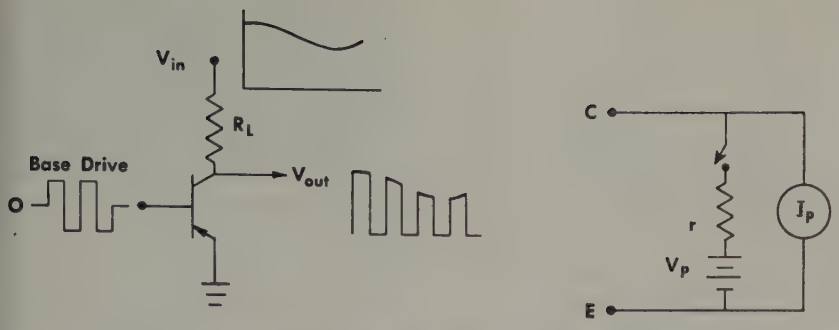

Fig. 72.1—Transistor chopper and its equivalent circuit.

tion region, k—the Boltzmann's constant (1.38×10^{-23} joule/°K), q—electric charge (1.60×10^{-19} coulombs), and T—operating temperature in °K.

In the inverted connection the offset voltage is

$$V_{PI} = -\frac{kT}{q} \ln \frac{1}{\alpha_N} = -\frac{kT}{q} \ln \left(1 + \frac{1}{\beta_N}\right) \quad (4)$$

where α_N and β_N are the normal forward current transfer ratios measured near the saturation region on the transistor V-I curve.

A comparison of equations 3 and 4 shows that since the coefficient kT/q is common to both, the offset voltage is determined by the natural logarithm of the quantity $(1+\frac{1}{\beta})$. Since the inverse beta of an unsymmetrical transistor is smaller than the normal beta, the offset voltage of the inverted connection will be lower.

The offset voltage is also a function of base drive because of the beta dependence on base current. Therefore the inverted connection with a properly selected driving current will produce the lowest offset voltage in a single transistor chopper. Such a chopper is show in *Fig. 72.2*. This circuit will chop all negative input signals as well as positive inputs of lower amplitude than the base voltage holding the transistor off.

Offset Current

The offset current is the current flowing between the collector and emitter when both junctions are reverse biased. The magnitude of this current is determined by the normal leakage currents (I_{EBO} and I_{CBO}) and the forward current transfer ratios measured near the cutoff region.

Again the inverted connection produces better circuit performance because of its lower offset current. The offset current is also somewhat temperature compensated by the increase in both the normal and inverse betas with temperature. Since the output voltage of the single-transistor chopper in *Fig. 72.2* with the transistor turned off is the input voltage minus the $I_{PI}R_L$ drop, the value of the load resistor in this circuit should be kept as low as possible.

Dynamic Resistance

When the chopper is switched on, the operating point of the transistor is located in the saturation region of the output characteristic V-I curve. The saturation characteristic has a finite slope and, therefore, has resistance associated with it. The instantaneous voltage drop across this resistance either adds to the offset voltage or subtracts from it, depending upon the polarity of the input signal.

The dynamic resistance in the normal connection is about 5% to 10% lower than in the inverted circuit. Thus only minute reduction in the dynamic resistance can be gained by the normal connection and this is far outweighed by the considerable reduction in the offset voltage and current in the inverted connection.

Switching Time

The highest rate of chopper operation is determined by the switching characteristics of the transistors used in the circuit. The emitter-to-collector voltage response of a transistor used in the inverted connection to a base drive voltage polarity change is shown in *Fig. 72.3*. After the forward bias is applied to the base, the emitter voltage decreases exponentially to its steady state value and remains there as long as the base drive remains unchanged. When the base voltage polarity is suddenly changed, the collector voltage will remain constant for a short interval and then increase abruptly to the base voltage level producing a voltage spike to the output. After that, the emitter voltage will decay to the level of the emitter supply voltage. The duration of all transients is a function of base drive and transistor characteristics.

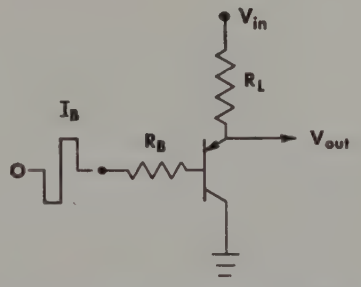

Fig. 72.2—Single-transistor chopper (inverted connection).

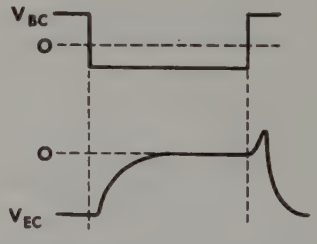

Fig. 72.3—Transistor switching transients (PNP transistor in the inverted connection).

APPLICATIONS ENGINEERING DIGEST NO. 73

(Circle 200 on Reader Service Card)

Thin Film Memory; Burroughs, Electronic Components Div., Plainfield, N. J.

Films which are deposited on a substrate while under the influence of a magnetic field show a preferred, or "easy," direction of magnetization. All area magnetic domains lie parallel to the direction of this field, and a film's magnetic characteristic in the preferred direction shows a square hysteresis loop. Perpendicular to this easy direction, called the "hard" direction, the film shows a linear loop (*Fig. 73.1*). From these two characteristics, the following constants can be obtained: The wall coercive force in the easy direction, H_C and the rotational saturating force in the hard direction, H_K.

Any magnetic square-loop material can be used as a storage element in a random-access memory. The unique geometry, directional magnetic properties, and rotational remagnetization process are characteristics which must be considered in the design of thin-film memories.

The principles of the memory operation are best explained by the discussion of a single bit. Three conductors are associated with each bit (*Fig. 73.2*). The "word drive" conductor is parallel to the preferred direction and the "information" and "sense" conductors are parallel to the hard direction. The information conductor is split for two reasons. One, it reduces the mutual ca-

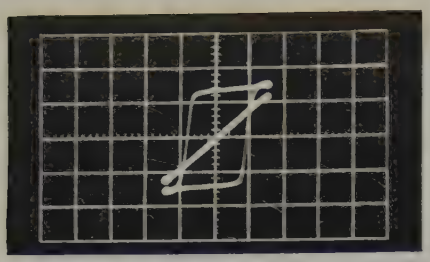

Fig. 73.1—Typical square and linear loops.

pacity between the information and the sense conductors and, second, it reduces eddy currents in the information conductor induced by the word drive current.

A current in the "word drive" conductor generates a transverse field, H_T, which, if greater than H_k, rotates the magnetic moments or dipoles to the hard direction. This rotation induces a sense signal of positive polarity if the rotation originated from the "1" state and of opposite polarity if it originated from the "0" state.

To magnetize a selected area of thin-film to the "1" or "0" state, two magnetic fields, perpendicular to each other, are applied—the drive field in the hard direction and the information field in the easy direction. The resultant field lies between the hard and easy directions, oriented toward either "1" or "0," depending upon the direction of the information field. Removal of the drive field allows the dipoles to fall to the desired "1" or "0" state, after which the information field can be terminated.

Waveforms of drive, information current, and sense signal are shown in *Fig. 73.3*

Applications Information

It is recommended that the sense and information line of pairs of planes be

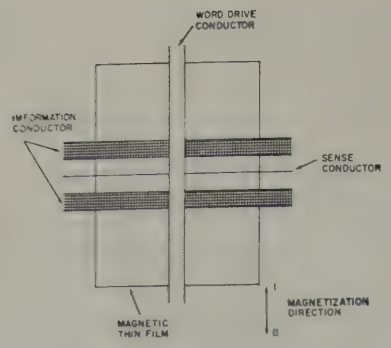

Fig. 73.2—Wiring of a bit.

interconnected in a noise-cancelling manner as shown the *Fig. 73.4.* This wiring arrangement minimizes noise, but the sense readout signal for a stored "1" in one plate and for a stored "1" of the other plate will be of opposite polarity. The logic circuits in either the sense amplifier or in the information driver can be designed to compensate this polarity reversal automatically.

Noise originating from ground currents can best be minimized by use of a common ground plane: a thin copper or aluminum plate, for example.

Shielding against the earth's magnetic field is recommended. A single layer of soft iron material can help considerably.

A transformer or a differential amplifier is suggested to reject the common-mode noise signal. Without it, the detection of the desired switching signal might be difficult. For example, a

Fig. 73.4—Interconnection of conductors to minimize noise.

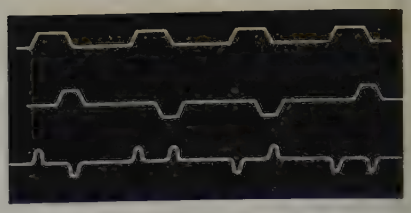

Fig. 73.3 — Waveforms — word drive (top); information (middle); and sense signal (bottom).

type F304 ferrite core (General Ceramics) T-1 type material with four turns primary and eight turns secondary gives good results. The transformer should be terminated with a 300-ohm load to eliminate ringing in the sense line. Sector windings or distributed windings are used. Sector-wound cores have a slower response, but their fabrication is easier.

Signals from a memory plane can be obtained for observation purposes if a fast rise time current generator is available (Hewlett-Packard type 212). The current driver should deliver a 1-amp. pulse into a terminated line. This current is applied to one of the word drive conductors. A d-c bias of plus or minus 200 ma. can be applied to one of the information conductors. A signal should appear on the corresponding sense winding. When the polarity of the bias current is reversed, a reversal of the sense signal should be noticeable. Oscilloscope sensitivity should be five mV/cm. Short cables and leads and elimination of ground current loops will produce clean thin-film switching signals.

Transmission-line principles must be utilized when high-speed current pulses have to be transmitted through some length of conductors to prevent ringing in these lines which could obscure the desired output signal.

Semiconductor Production And Trade

This report is reproduced from portions of a pamphlet prepared by the Electronics Division of the Business and Defense Services Administration, U.S. Department of Commerce.

This report on semiconductor production and trade is part of a comprehensive study of the electronic industries being made by the Business and Defense Services Administration. Based to a large extent on information derived from BDSA activities in the industrial mobilization preparedness field, it is made available to industry for marketing and planning purposes as part of this Agency's expanding program of business services. A special survey conducted by the Department of Defense in connection with an investigation of the impact of semiconductor imports was the source of much of the statistical data.

This report was prepared in the Electronics Division, Donald S. Parris, Director, by John R. Collins, Chief, Military Applications Branch. The assistance of various members of Government and industry is gratefully acknowledged.

The increasing use of transistors and crystal diodes in electronic

circuitry is responsible in part for a decline in U.S. receiving tube production from 491 million units in 1955 to 463 in 1956, 454 in 1957, and 411 in 1958. Output increased slightly, to 437 million units, in 1959.

The size of the receiving tube market in terms of units does not provide an accurate picture of the potential market for transistors and diodes. Tubes usually have higher gain than transistors, and many tubes are multifunctional, so that several transistors may be needed to replace a single tube. Transistors can be used in quantity in circuits where space, weight, and available power would limit the use of tubes. Thus, transistors are being employed in new applications in which tubes could not be used at all. On the other hand, where space, weight, and power are unimportant, as in console radios, television receivers, and high fidelity sound equipment, receiving tubes will probably continue to be used for many years.

Until recent years, transistors were used chiefly for hearing aids, portable radios, and experimental purposes. Improvements in performance and reliability have led to their increasing military and industrial utilization. They are now widely used in missiles, communication networks, weapons systems, electronic computers, and industrial controls. Crystal diodes and rectifiers are also being used in new ways in both military and industrial equipment.

The transistor market in 1959 was divided approximately as follows (percent):

	Units	Value
Entertainment	54	17
Industrial	24	34
Military	17	46
Export	5	3

The differences between unit and value percentages reflect the fact that the factory price of entertainment type transistors averaged less than $1 each while military types averaged in excess of $7. Industrial type transistors averaged almost $4 each.

Military utilization of crystal diodes and rectifiers amounted to about 31 percent by units and 45 percent by value of total shipments in 1959. Only about 2 percent, by either quantity or value, were exported. The rest were used in entertainment, commercial, and industrial equipment.

Plant Facilities

As of April 1960, more than 60 companies were producing semiconductors, in about 100 plants. Although many of them maintained separate facilities for research and development (R & D), parts of most production plants were used for R & D (table 1). Many of the plants make other products in addition to semiconductors, but the floor area shown, broken down into production and R & D, is only that portion devoted to semiconductors. Production workers are defined as working foremen and all non-supervisory workers engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, shipping, maintenance, repair, janitorial and watchmen services, product development, auxiliary production for the plant's own use (e.g., power plant), and record-keeping and other services closely associated with the production operations.

Table 1.—Floor Area of Semiconductor Plants
[Millions of square feet]

	12/15/58	12/15/59	4/15/60
Production of semiconductors	2.6	3.5	3.9
Research and development for semiconductors	0.7	0.9	1.0
Total	3.3	4.4	4.9

Source: Department of Defense Survey, May 1960.

Twenty companies accounted for about 94 percent of semiconductor factory shipments in 1959 (table 2). These statistics were derived by listing the leading manufacturers according to the dollar volume of their 1959 factory shipments and computing the percentages contributed by the largest 3, 5, 10, 15, and 20 companies. The greatest concentration of semiconductor production is in Massachusetts, which accounted for almost 24 percent of total factory shipments in 1959. Pennsylvania shipments represented about 16 percent and New York shipments, 9 percent. Texas, California, and New Jersey were also large production areas, but their shipments cannot be reported for disclosure reasons.

Table 2.—Concentration of Factory Shipments of Semiconductors, 1959

Number of Manufacturers	Cumulative percent
First 3	39
First 5	52
First 10	73
First 15	85
First 20	94

Source: Estimated from Joint EPRA/BDSA Semiannual Survey of Production Capabilities for Electronic Parts.

About 60 percent of the companies responding to a May 1960 Department of Defense survey indicated that they planned to expand their semiconductor facilities in the next 2 years, in which case semiconductor manufacturing and R & D facilities will be approximately doubled by the end of 1962 (table 3).

Table 3.—Planned Expansion of Semiconductor Facilities
[In millions]

Type	May December 1960		1961		1962		Total	
	Square feet	Dollars	Square feet	Dollars	Square feet	Dollars	Square feet	Dollars
Production of semiconductors	1.5	42.0	1.0	44.4	1.6	72.0	4.1	158.4
Research and development for semiconductors	0.3	9.0	0.5	16.5	0.4	12.0	1.2	37.5
Total	1.8	51.0	1.5	60.9	2.0	84.0	5.3	195.9

Source: Department of Defense Survey, May 1960.

PRODUCTION

Manufacturing Processes

Ingots of germanium are formed by heating a powdered oxide of germanium in graphite crucibles in a hydrogen atmosphere. The oxygen in the germanium oxide combines with the hydrogen and is given off as water vapor, leaving metallic germanium. Zone purification is usually used to achieve the required degree of purity. This involves drawing the ingot slowly through successive induction heating coils which melt a small segment at a time, beginning at one end and passing to the other. Impurities tend to remain in the molten state and are thus carried to the end of the ingot. By repeating the process over and over, any desired degree of purity can be achieved. The end containing the impurities is then snipped off and the rest of the ingot is used for transistor manufacture.

The purification of silicon is much more difficult. It has a higher melting temperature (1420 degrees C as compared to 940 degrees C for germanium) and is chemically very active when in the molten state. It thus combines readily with materials generally used as containers, such as carbon and quartz. It expands when cooling and this results in cracking the crucible and in poor quality silicon as a result of the severe strain. Furthermore, some impurities, especially boron, cannot be satisfactorily removed by the zone purification process. Several purification methods have been devised which produce satisfactory results, but they are much more difficult and expensive than germanium purification processes.

The purified metal is next doped and grown into a single crystal. A small piece of single crystal, called a seed, is dipped into a crucible containing the molten metal and slowly withdrawn. If temperature conditions are properly maintained, a crystal of the same orientation will grow on the seed until all the metal in the crucible is exhausted. Doping is achieved by adding impurities to the molten metal at the proper rate.

The degree of doping is determined by measuring the resistivity of the crystal. High purity germanium has a resistivity of 40 to 50 ohms per centimeter. After doping, its resistivity should be from 2 to 4 ohms per centimeter. Segments of the crystal having a different resistivity are removed and reprocessed.

The orientation of the crystalline structure is determined and the crystal is then sliced into thin slabs with diamond saws. These slabs are lapped to the required final thickness—generally 7 to 8 mils—and then cut into wafers. The size of the wafer depends on the type of transistor being made.

Junctions are made in a number of different ways. One method involves placing indium pellets on each side of an *n*-type wafer and applying heat. The indium dissolves partially into the wafer and forms *pn* junctions. The depth of penetration is controlled by controlling the temperature and the heating time. The result is a *pnp* transistor element. Leads are soldered to each indium dot and to the wafer base, and the assembly is etched to remove surface metal which might have become contaminated. It is then attached to the terminals of a header assembly and a case is welded on. The final operations are carried on in a controlled atmosphere to prevent contamination after the final etching.

Completed transistors are subjected to elaborate tests. Small variations in the resistivity of the base material or in the depth of penetration of the molten indium or in the positioning of the leads affect frequency, power, and gain characteristics of the transistor. Uniformity is achieved by sorting transistors into separate categories according to their characteristics.

Automatic Production

Though transistor production involves much hand labor, certain advances toward automatic production have been made. Purification of germanium and silicon, though not unattended, is largely automatic, depending on precise temperature control and timing of conveyor mechanisms to achieve acceptable results. This is also true

of crystal growing techniques. After the ingots have been properly oriented and positioned in the machine, the actual slicing is automatic, as is the lapping process.

Dicing the slices into wafers and sorting them according to size is usually a hand operation. Machines are used, however, to sort the wafers automatically according to their thickness.

Automatic machinery has been developed which will etch the wafers to the required thickness, alloy indium pellets to the wafers, attach and solder leads, etch away the excess indium, weld the units in header assemblies, perform the final etching, and seal the units into cases. These developments have not only reduced the number of production workers needed on an assembly line but have also resulted in more uniform quality.

Automated lines are in limited use because they are not versatile enough to produce the many types of transistors in current use and because technology is advancing so rapidly that manufacturers hesitate to make large investments in equipment to produce types of transistors which may become obsolete before the equipment development and production costs are recovered. Also, saving in production workers is offset to some extent by the need for additional technicians to maintain the equipment. Automatic assembly equipment will be used more extensively in the future as more transistor designs become stabilized.

Much of the testing and sorting is performed automatically. However, when transistors with other than conventional characteristics are desired, manual testing is necessary. Testing for quality-control purposes is principally manual. Since small variations in temperature, atmosphere, or timing can affect the product, tests are made at frequent intervals throughout the operation.

Progress has been made in growing single crystals in long ribbons which are doped for the desired *pn* junctions. This method promises to eliminate much of the mechanical labor and materials wastage involved in slicing, lapping, dicing, and sorting of transistor base materials.

Employment

Semiconductor employment and payrolls in 1958-60 are shown in table 4. Multiproduct plants reported production workers and engineers and scientists engaged in semiconductor work separately from workers concerned with other products. However, "other" workers were not separately reported and the proportion had to be estimated. Out of each 10,000 manufacturing workers, 17 were employed in semiconductors in 1958 and about 26 in 1959. Engineers and scientists comprised more than 10 percent of all semiconductor employees in 1958, more than 11 percent in 1959, and almost 13 percent by April 1960. Engineers and scientists were defined as those persons engaged in scientific or engineering work at a level requiring a knowldge of the physical, engineering, or mathematical sciences equivalent at least to that acquired through completion of a 4-year college major in those fields.

Table 4.—Semiconductor Employment and Payrolls
[Employment in units; payrolls in $1,000]

	1958		1959		January-April 1960	
	Employment	Payroll	Employment	Payroll	Employment	Payroll
Production workers	20,000	72,000	30,100	113,500	34,700	45,000
Engineers and scientists ..	2,800	22,500	4,900	39,500	6,200	17.000
Other	4,100	21,600	6,700	40,000	7,800	18,500
Total	26,900	116,100	41,700	193,000	48,700	80,500

Source: Department of Defense Survey, May 1960.

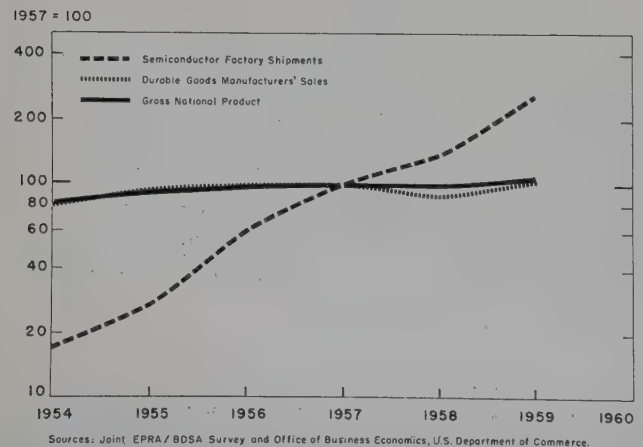

Fig. 1. Factory Shipments of Semiconductors, Manufacturers' Sales of Durable Goods, and Gross National Product, 1954-59.

Shipments and Prices

Semiconductor factory shipments increased more than 15 times in value in the period 1954-59, while the value of manufacturing sales in the durable goods industry increased about 29 percent and the gross national product 32 percent (table 5 and figure 1). Shipments of both transistors, and crystal diodes and rectifiers expanded rapidly, but transistors made larger gains (table 6). The distribution of shipments for military and non-military uses is shown in figure 2.

Table 5.—Factory Shipments of Semiconductors, Manufacturing Sales in the Durable Goods Industries, and Gross National Product, 1954-59

	1954	1955	1956	1957	1958	1959
Factory shipments of semiconductors (million dollars) ..	26.0	40.0	90.0	151.0	210.0	395.0
Durable goods manufacturing sales (billion dollars)	134.8	156.9	165.7	169.9	148.6	174.2
Gross national product (billion dollars)	363.1	397.5	419.2	442.5	441.7	479.5

Source: *Joint BDSA/EPRA Survey;* Office of Business Economics, U. S. Department of Commerce.

Table 6. Estimated U. S. Factory Shipments of Semiconductors, 1955-59
[Quantity in millions of units; value in millions of dollars]

Year	Transistors						Crystal diodes and rectifiers					
	Quantity			Value			Quantity			Value		
	Total	Military	Nonmilitary	Total	Military	Nonmilitary	Total	Military	Nonmilitary	Total	Military	Nonmilitary
1955	3.9	0.4	3.5	13.0	4.7	8.3	28.1	6.5	21.6	27.0	9.8	17.2
1956	14.7	1.1	13.6	40.0	12.2	27.8	48.0	12.8	35.2	50.0	19.5	30.5
1957	27.8	2.6	25.2	68.0	21.1	46.9	66.0	17.0	49.0	83.0	32.5	50.5
1958	46.1	4.7	41.4	112.0	37.1	74.9	74.8	21.7	53.1	93.0	43.9	54.1
1959	83.5	14.4	69.1	228.5	105.5	123.0	129.4	40.6	88.8	166.5	74.2	92.3

Source: Joint EPRA/BDSA Survey.

Table 7.—Semiconductor Prices, 1955-59
[In dollars]

Year	Transistors			Crystal diodes and rectifiers		
	Average	Military	Non-military	Average	Military	Non-military
1955	3.34	11.75	2.47	0.96	1.50	0.80
1956	2.72	11.10	2.04	1.04	1.52	0.87
1957	2.44	8.10	1.86	1.26	1.91	1.03
1958	2.43	7.90	1.81	1.32	2.02	1.02
1959	2.74	7.33	1.78	1.28	1.83	1.04

Source: Joint EPRA/BDSA Survey.

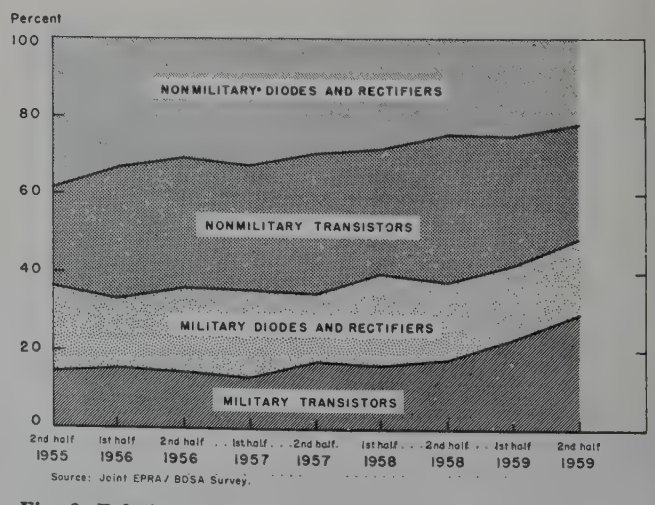

Fig. 2. Relative Distribution of Semiconductor Shipments—Military and Nonmilitary, 1955-59.

Factory shipments per employee amounted to approximately $7,800 in 1958 and $9,500 in 1959.

The greatest change in prices occurred in military transistors, which have dropped substantially in recent years (table 7). Even though prices of both military and nonmilitary types decreased in 1958-59, the average transistor price increased slightly, owing to the larger proportion of military transistors than in previous years. (The more sophisticated military types have a considerably higher unit value than either entertainment or computer types.) Both transistors, and crystal diodes and rectifiers comprise a large number of different devices, some quite expensive and many relatively cheap. Upward price trends usually reflect a greater proportion of expensive units or the development of new and more expensive types, rather than price increases in standard types.

RESEARCH AND DEVELOPMENT

The semiconductor industry, still in its infancy, is maintaining substantial R & D programs to improve the performance and reliability of semiconductor devices and to develop better production techniques. Several thousand different types of transistors and crystal diodes are already in use, and new types are being added daily as the result of improvements in design and materials, or to meet new requirements. Technological progress is so rapid that, even considering these gains, probably most of the semiconductor devices that will be required 5 years from now have not yet been developed.

A part of the research is being financed by the Governmnt through R & D projects and production-refinement projects, or Industrial Preparedness Studies (IPS) (table 8).

Table 8.—Estimated Funding of Programs in the Semiconductor Area, 1955-61
[In thousands of dollars]

	1955	1956	1957	1958	1959	1960	1961
Research and development	3,169	4,052	3,798	4,010	6,300	6,800	11,000
Industrial preparedness studies: transistors	2,710	14,000	0	1,900	1,015	0	1,650
Industrial preparedness studies: diodes and rectifiers	2,240	850	500	200	0	1,110	800
Total	8,119	18,902	4,298	5,910	7,315	7,900	13,450

Source: Department of Defense Advisory Group on Electron Tubes.

In addition, some of the funds spent by the Department of Defense for work on the development of weapons systems are passed on by prime contractors to components manufacturers. In order to obtain information on the size and source of R & D funds, the Department of Defense made a special survey in mid-1960 (table 9). The following definitions were used in obtaining the information:

Research and development: Basic and applied research in the sciences and in engineering, and design and development of prototypes and processes. It does not include quality control, routine product testing, market research, sales promotion, sales service, research in the social sciences or psychology, or other nontechnological activities or technical services. This definition includes:

Basic research: Research projects that represent original investigation for the advancement of scientific knowledge and that do not have specific commercial objectives, although they may be in fields of present or potential interest to the reporting company.

Applied research: Research projects that represent investigation directed to discovery of new scientific knowledge and that have specific commercial objectives with respect to either products or processes. This definition of applied research differs from the definition of basic research chiefly in terms of the objectives of the reporting company.

Development: Technical activity concerned with nonroutine problems that are encountered in translating research findings or other general scientific knowledge into products or processes. Not included are routine technical services to customers or other items excluded from definition of research-development above.

Table 9.—Research and Development Expenditures
[Millions of dollars]

	1958	1959	January-April 1960
Government funds, total	13.9	16.2	6.8
Department of Defense	12.6	14.4	6.3
Other	1.3	1.8	0.5
Company funds	41.8	54.6	25.4
Total funds	55.7	70.8	32.2

Source: Department of Defense Survey, May 1960.

The survey showed that R & D expenditures in 1959 amounted to about 18 percent of the value of factory shipments. The top five companies accounted for about 49 percent and the top 10 companies about 73 percent of the total. The Government furnished about 23 percent of the funds, and manufacturers the remainder (table 10).

The companies that maintain R & D facilities separate from their manufacturing facilities in December 1958 employed in these establishments more than 1,800 workers and occupied 485,000 square feet.

Table 10.—Concentration of R & D Expenditures, 1959
[In percent]

Number of firms	Government funds	Company funds	Total funds
First 3	53.7	30.2	35.6
First 5	74.0	42.1	49.4
First 10	89.5	68.2	73.2
First 15	93.7	83.0	86.0
First 20	96.5	89.4	91.0

Source: Department of Defense Survey, May 1960.

By April 30, 1969, employment increased to 2,300 workers and area to 641,000 square feet.

Manufacturers reported the value of real property and equipment used for semiconductor R & D increased from $37.4 million on December 31, 1958, to $52.8 million on April 30, 1960. On the latter date only $1.2 million of the facilities were owned by the Government.

FOREIGN TRADE

U. S. Exports of crystal diodes and transistors for the period 1954-59 are shown in table 11. Exports in 1959 amounted to little more than 3 percent by quantity and 2 percent by value of total U. S. factory shipments.

Table 11.—U.S. Exports of Crystal Diodes and Transistors, 1954-59
[Quantity in 1,000 units; value in $1,000]

Year	Quantity	Value
1954	194	334
1955	402	473
1956	750	1,171
1957	2,694	4,230
1958	5,785	7,778
1959	6,651	9,159

Source: Report No. FT-410, *United States Exports of Domestic and Foreign Merchandise*, Bureau of the Census, U.S. Department of Commerce.

Canada, Italy, and Australia were the best U. S. customers in 1959, accounting for 17, 12, and 10 percent, respectively, of the value of U. S. exports. Unit prices to different countries varied widely, the more costly units usually being purchased by the more highly industrialized countries. The average unit price of semiconductor exports to the United Kingdom was $4.10, for instance, but to Brazil, only 73 cents. Japan purchased 134,000 units for $550,000 at an average of about $2.42.

Semiconductor imports are not shown separately in U. S. statistics. However, practically all such imports so far have come from Japan (table 12). Japanese semiconductor shipments to the United States in 1959 of 3 million units valued at $1.7 million amounted to 1.4 percent of the units and about 0.4 percent of the value of total U. S. factory shipments.

Table 12.—Japanese Semiconductor Exports to the United States, 1956-59
[Quantity in 1,000 units; value in $1,000[1]]

Item	1956		1957		1958		1959	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Semiconductors total	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2,990	1,673
Transistors	([2])	4	1	1	11	7	2,393	1,581
Other semiconductor devices	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	597	92

n.a.—Not available.
[1]Conversion at the rate of 360 yen = US$1.
[2]Fewer than 500 units.

Source: Japanese Ministry of International Trade and Industry.

Unit prices of Japanese semiconductor imports in 1959 averaged about 66 cents for transistors and 16 cents for crystal diodes. This level is far below average U. S. prices and reflects the Japanese concentration in the low-cost, entertainment-type semiconductors. The United States was by far Japan's best export market in 1959, accounting for more than half of its total exports of semiconductor devices. In addition to transistors as such, Japan in 1959 shipped to the United States radios containing an estimated 22 million transistors.

Slide Calculator Cutouts

(See page 26)

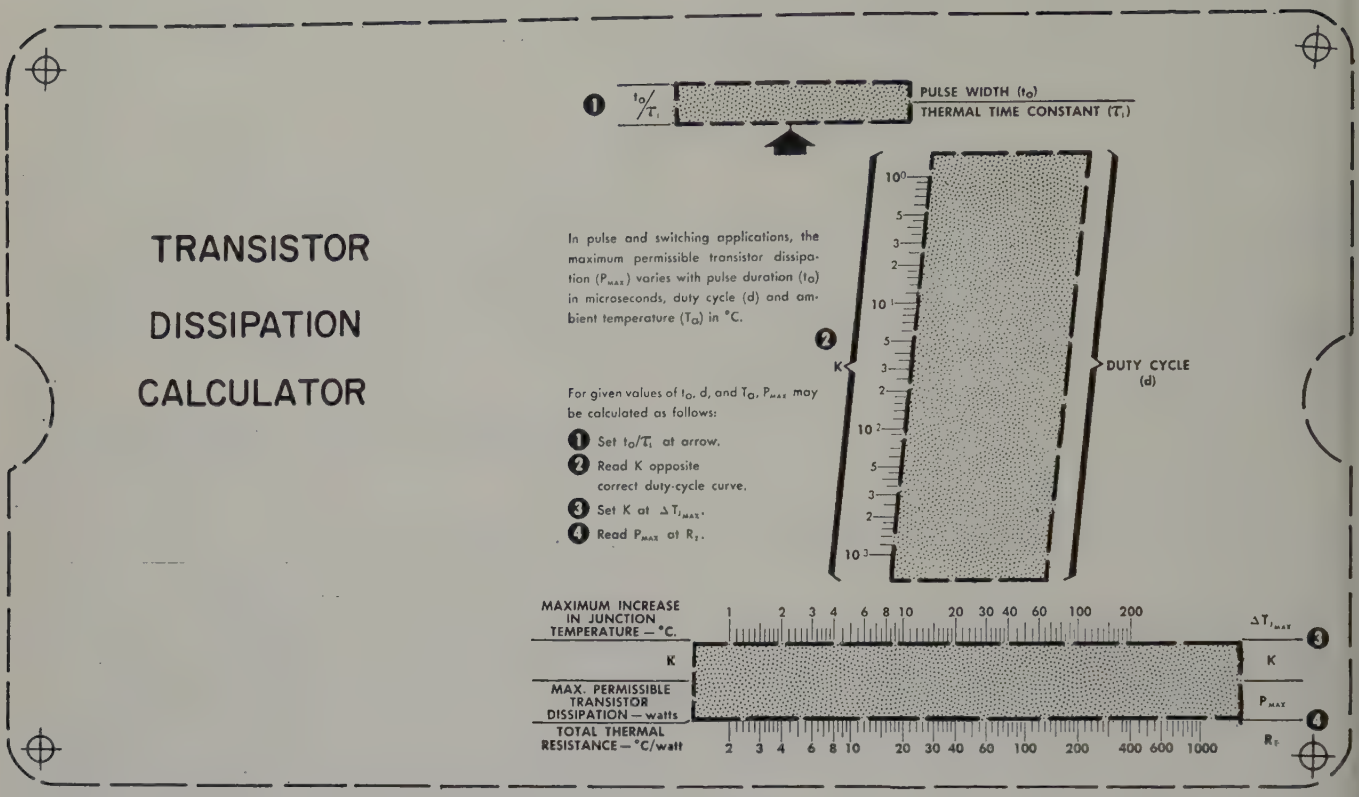
TRANSISTOR
DISSIPATION
CALCULATOR
1 t_o/τ_1
PULSE WIDTH (t_o)
THERMAL TIME CONSTANT (τ_1)
In pulse and switching applications, the maximum permissible transistor dissipation (P_{MAX}) varies with pulse duration (t_o) in microseconds, duty cycle (d) and ambient temperature (T_A) in °C.
For given values of t_o, d, and T_A, P_{MAX} may be calculated as follows:
1 Set t_o/τ_1 at arrow.
2 Read K opposite correct duty-cycle curve.
3 Set K at $\Delta T_{j_{MAX}}$.
4 Read P_{MAX} at R_2.
2
K
DUTY CYCLE (d)
MAXIMUM INCREASE IN JUNCTION TEMPERATURE — °C.
K
MAX. PERMISSIBLE TRANSISTOR DISSIPATION — watts
TOTAL THERMAL RESISTANCE — °C/watt
$\Delta T_{j_{MAX}}$
3
K
P_{MAX}
4
R_T

Fig. 1—Front of calculator.

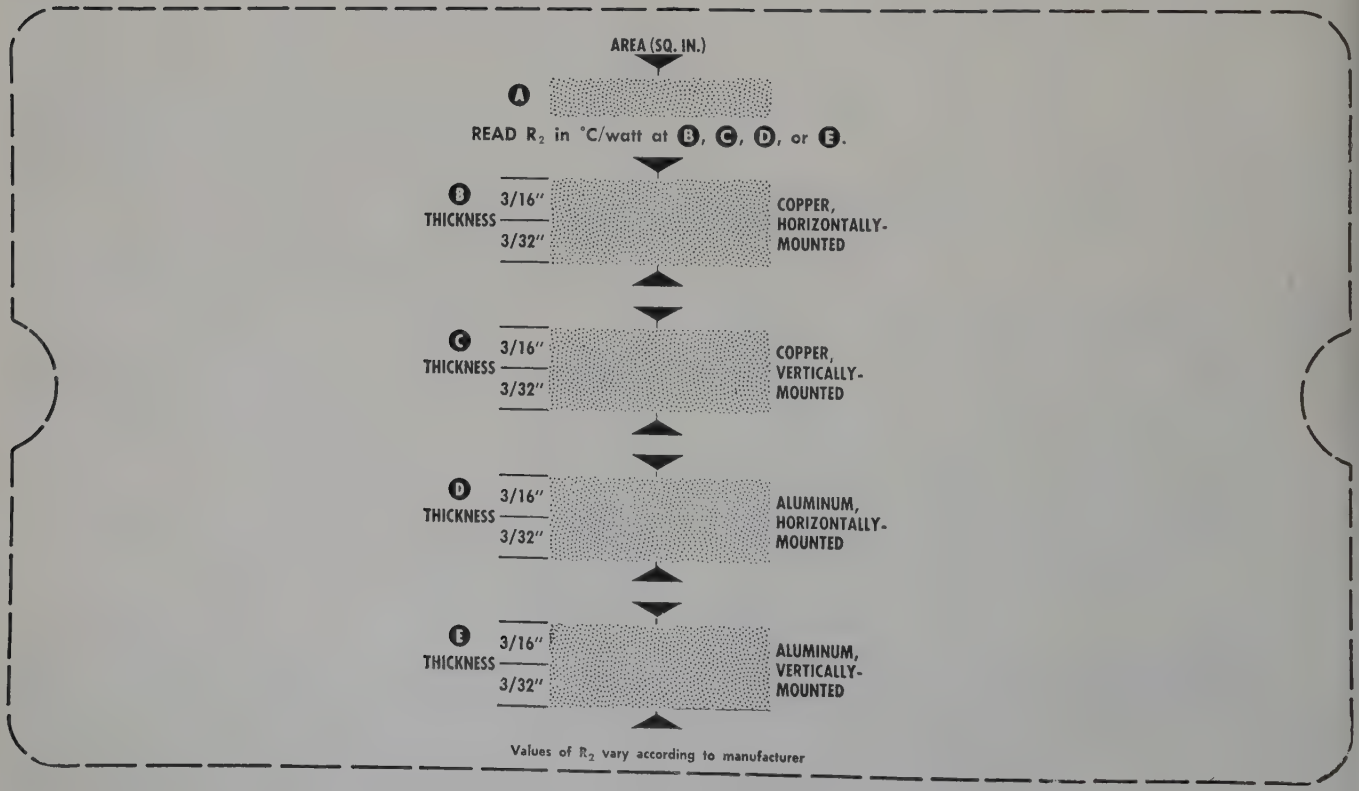

Fig. 2—Back of calculator.

Slide Calculator Cutouts

(See page 26)

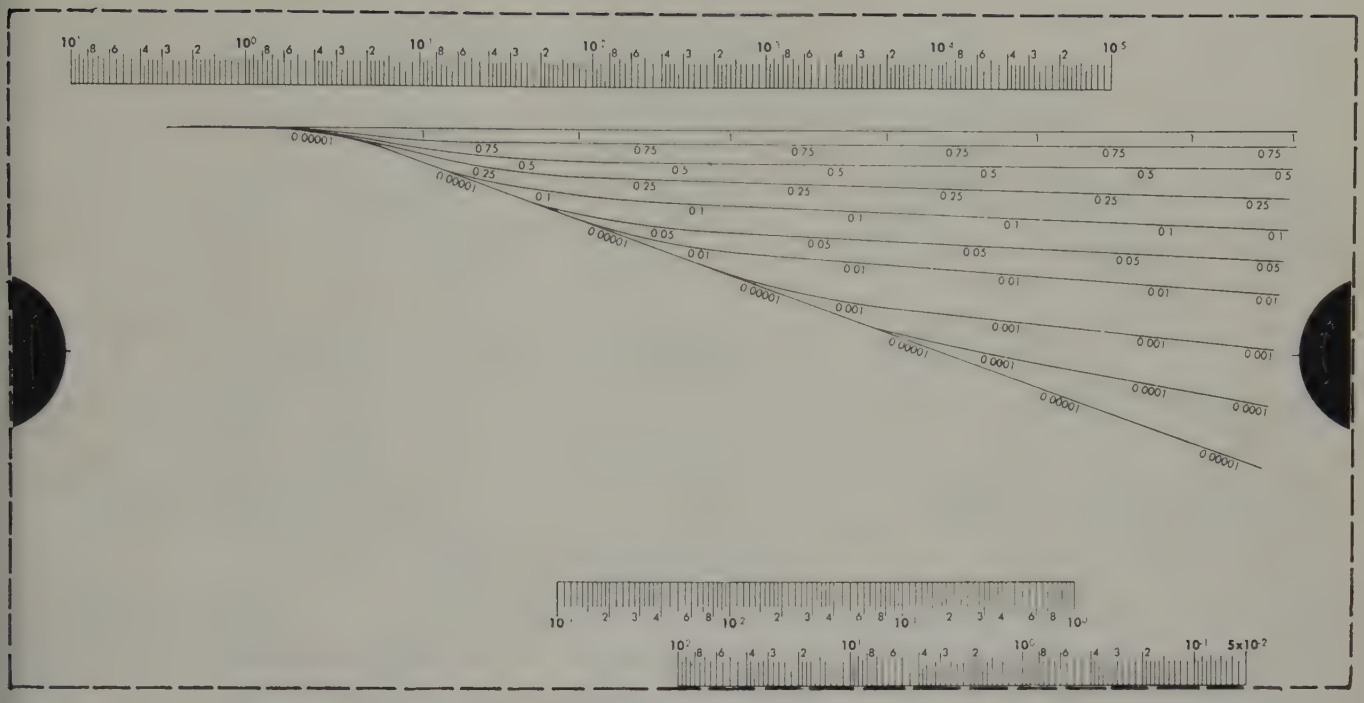

Fig. 3—Front of sliding insert.

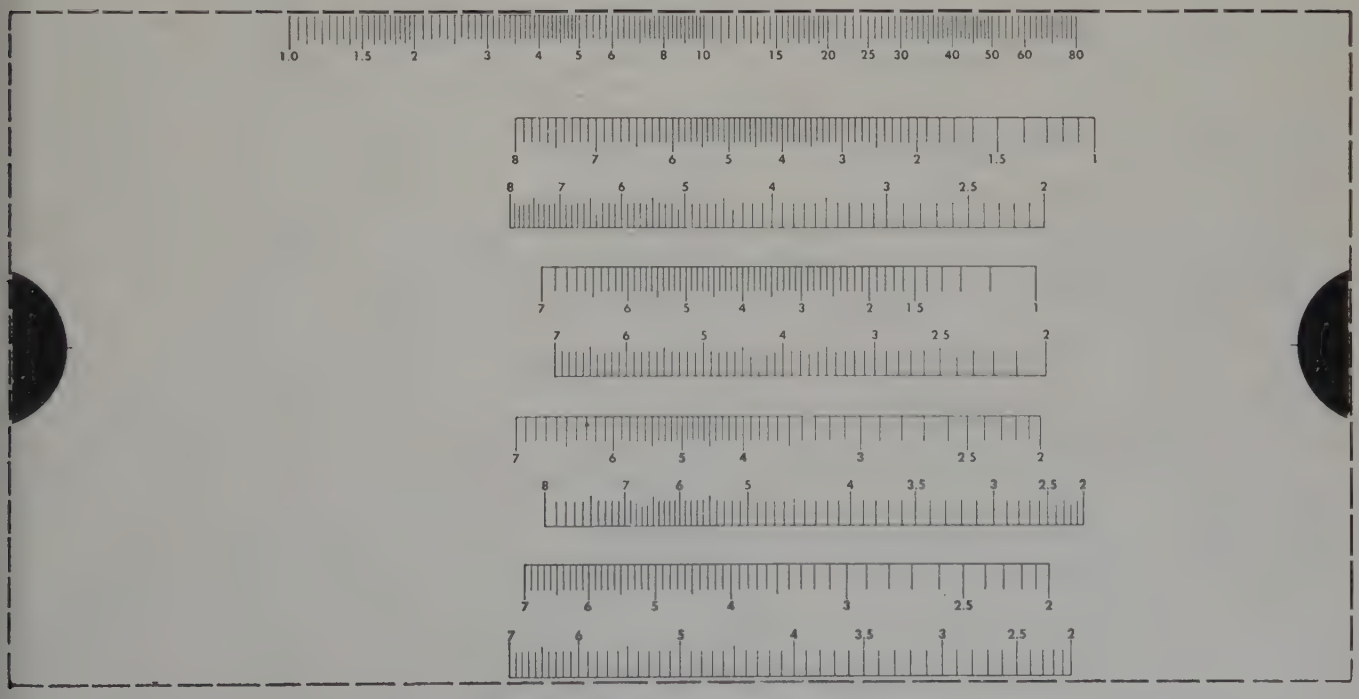

Fig. 4—Back of sliding insert.

SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Easy Glide of Lead Single Crystals	Acta Metallurgica March 1961	Lead single crystals like those of other f. c. c. metals show easy glide, the amount increasing with the quantity of dissolved impurity, and decreasing with the content of insoluble impurity.	R. L. Fleischer
Silicon Controlled Rectifiers in a D-C Servo System	App & Ind (AIEE) March 1961	Results of designing, building, and testing a servo system which incorporates the controlled rectifiers as the power amplifier for the d-c servomotor.	C. Cantor
Relation Between Surface Concentration and Average Conductivity in Diffused Layers in Germanium	Bell Syst Tech JL March 1961	An expression is derived for calculating the average conductivity of a diffused layer in semiconductor material as a function of the surface concentration of the diffused impurity and the background impurity concentration.	D. B. Cuttriss
Germanium High Frequency Mesa Transistors	Brit Comm & Elecncs March 1961	Some of the difficult problems of manufacturing control are outlined. Advantages offered by mesa construction for h-f applications are discussed.	R. E. Warren
Galvanomagnetic Effects and their Application	Br JL Appd Physics March 1961	The simple theory of Hall effect and magnetoresistance is discussed. The use of various semiconductors for galvanomagnetic applications is considered, and some practical applications described.	C. Hilsum
The Preparation of Thin Films of Germanium and Silicon	Br JL Appd Physics March 1961	Films about 1000 angstroms thick, suitable for observing dislocations by transmission electron microscopy, have been prepared from the brittle semiconductors, germanium and silicon, by a combination of mechanical polishing and chemical etching.	B. A. Irving
Hybrid Parameters Simplifies Calculation of Transistor Current Gain VS Load	Canad Elecncs Engg Feb 1961	The computation required to construct the forward current gain versus load admittance curves of a 4-terminal network is greatly reduced if the output hybrid paramemter of the network is measured. The theory is illustrated by application to a transistor.	M. A. Gullen
Phonon Drag in Lead	Canad JL Physics March 1691	Measurements have been carried out on the thermoelectric power of dilute alloys of lead with the solutes Cd, In, Sn, Tl, and Bi, in order to test a plausible hypothesis that much of the thermoelectric behavior of pure lead at low temperatures can be ascribed to phonon drag.	A. V. Gold W. B. Pearson
Magnetoresistance and Hall Effect in Oriented Single Crystal Samples of N-Type Indium Antimonide	Canad JL Physics March 1961	Measurements have been made on the angular dependence of the magnetoresistance effect and the Hall Effect on oriented n-type indium antimonide samples.	C. H. Champness
Control in Transistor Converter Circuit by R-C Networks	Comm & Elecncs (AIEE) March 1961	A new type of adjustable-frequency transistor converter circuit is described. In this circuit the operating frequency is independent of the applied direct voltage, not proportional to it.	F. V. Kadri
Transistor Switches For Industrial Service	Control Engg March 1961	Report on how transistors perform logic functions; looks at available systems and components; gives tips on selectron and use; and shows case studies of transistor logic at work in industry.	J. C. Sturman
Tunnel And Uni-Tunnel Diode Applications	Elecl Design News March 1961	A number of various circuit application of these devices are presented.	EDN Staff Report
Transistor Resistor Logic Circuits	Elecnc App (Neth) Vol 21 No. 1 (1960-1961	Design of a basic transistor resistor logical circuit is described, and the design and performance equations are derived.	P. D. T. Hawker
H. T. Supply Units for Television Receivers Equipped with Silicon Diodes	Elecnc App (Neth) Vol 21 No. 1 1960 1961	Fundamental parameters applicable to single-phase and two-phase wave rectification, and voltage doubler circuits R-C network smoothing are exhaustively investigated.	J. F. van Dam L. A. L. Esseling A. M. H. Schellekens A. P. Tanis
Transistor Switching Speed From Base Storage Charges and their Lifetimes. Part 1	Elecnc Design March 15, 1961	Brief review of the charge-controlled mechanism. Analytical relations between switching speeds, charges, and lifetimes. Charge measurement techniques described.	Y. C. Hwang D. S. Cleverley D. J. Monsour
All Solid-State Proportional Control Temperature Servos Can Be Simpler, Better	Elecnc Design March 15, 1961	A thermistor can be used as the sensor, a Zener diode as the reference, transistors as amplifiers, and resistors as actuators.	P. Gheorghiu
A Survey of Parametric Amplifiers	Elecnc Design March 15, 1961	Discussion of types of parametric amplifiers, and classification of characteristics.	A. Szerlip
Electronic Commutators	Elecnc Design March 29, 1961	Circuit discussion includes basic gating circuits using either diodes or transistors.	Staff Report
Electroluminescence—Its Characteristics and Applications, (Part 2)	Elecnc Engg March 1961	The cell as a source of illumination; information display systems; the electroluminescent matrix; thin screen TV; light amplification; and photo-conductive elements.	D. H. Smith
Operation and Logic of Diode Transistor Switching Circuits	Elecnc Equip Engg March 1961	Four basic types of diode-transistor logic circuits are treated for their operation mode and building block logic.	R. B. Hurley
Charge Storage Techniques for High Speed Switching Circuits, Part I	Elecnc Equip Engg March 1961	First of three part series shows use of charge storage design methods for high speed pulse amplifiers; flip-flop and inverters of both saturating and non-saturating types.	J. F. Martin F. Niertit J. Shirman
Designing Mesa Transistor Circuits	Elecnc Equip Engg March 1961	Power oscillators and Class-C amplifiers for frequency range from 10 to 200 mc can be designed using basic circuits and design charts.	W. A. Rheinfelder
Power Loss Vs. Frequency in D-C to D-C Converters	Elecnc Industries March 1961	A discussion of how switching time and peak voltage affect a power transistors efficiency.	R. Greenburg
Silicon Rectifier Design Techniques	Elecnc Industries March 1961	Three general methods for series operation in high voltage applications, and three general methods for parallel operation, where high current rectification is needed.	R. Lynch
Designing Chopper-Stabilized Operational Amplifiers	Electronics Mar 3 1961	This article deals with drift stabilization techniques, with emphasis on practical design application.	R. B. Fradella

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Logic Combines Tunnel Diodes with Transistors	Electronics Mar 3 1961	Switching speed of tunnel diodes, and isolation capabilities of transistors are combined to obtain logic having switching times of 0.7 nanosecond.	R. W. Lade
Designing Thin Magnetic Film Memories for High Speed Digital	Electronics Mar 3 1961	Memory planes using nickel-iron films 2,000 angstroms thick are made reproducibly by vacuum deposition on glass. Design of transistorized driving circuits is discussed.	E. E. Bittman
Solid-State Modulators for Infrared Communications	Electronics Mar 10 1961	The heart of the communications system described here is a semiconductor device that modulates infrared radiations.	P. W. Kruse L. D. McGlauchlin
Two-Stage Line-Wave Clipper	Electronics Mar 17 1961	Square waves can be generated from sine waves by symmetrical clipping. Flatness of wave tops is increased by adding a second stage at output.	W. E. Nemeth
Wideband Transistor Preamplifier Handles Low-Resistance Transducers	Electronics Mar 17 1961	Readout from magnetic heads and other low-level signal sources is constant within plus or minus 3 db over the range of 10 cycles to 1 mc. Details of circuit design are presented.	S. R. Parris
Electroluminescent Display and Logic Devices	Electronics Mar 24 1961	Photoconductive and electroluminescent techniques are combined in a group of devices that can be used for visual readout displays, and as complex logic circuit elements.	I. Greenberg
Tunnel-Diode Pulse Compressor Preserves Superimposed Signal	Electronics Mar 24 1961	Circuit compresses video pulse ampliture by 12 db without affecting any small superimposed signals or overloading components.	A. A. Clark W. H. Ko
Measuring Semiconductor Junction Capacitance	Electronics Mar 24 1961	Capacitance measurement techniques include Q meter and reactance drop methods.	G. C. Summers
Using Epitaxial Transistors in Switching and R-F Circuits.	Electronics Mar 31 1961	Circuits made use of epitaxial transistor characteristics. Applications considered are for high speed computers and VHF amplifiers.	D. Hall
Designing Amplifiers with Nonlinear Feedback.	Electronics Mar 31 1961	Nonlinear feedback look provides a way to modify the characteristics of a transistor amplifier. Design criteria are presented.	J. C. Looney
Cooling Transistors with Thermoelectric Elements	Electronics Mar 31 1961	Thermoelectric coolers can be used for local cooling of hot transistors. Results of using these elements on transistors operated below and above their maximum rated junction temperatures are discussed.	J. R. Fortier C. S. Thompson
Transistor Frequency Response	Elecnc Technology March 1961	Recent transistor specifications usually include typical values of Ft. This article describes a graphical presentation of ft as a functional of the d-c working point, and advantages of this method.	J. R. James D. J. Bradley
Semiconductor Electronics 6—Non-Linear and Switching Operation	Electro-Technology March 1961	Switching is considered both as a static and a dynamic operation.	A. A. Sorensen
Electron-Emission Microscope and Velocity Distribution Studies on Silicon Carbide p-n Junction Emitters	JL Appl Phys March 1961	Electron emission from reversed biased p-n junctions in silicon carbide is discussed.	P. H. Gleichauf V. Ozarow
Extended Curves of the Space Charge, Electric Field, and Free Carrier Concentration at the Surface of a Semiconductor, and Curves of the Electro Static Potential Inside a Semiconductor.	JL Appl Phys March 1961	A graphical presentation as described.	C. E. Young
Growth Twins In Indium Antimonide	JL Appl Phys March 1961	Twinning is almost always observed where the speed presents (111) B surfaces to the melt.	R. K. Mueller R. L. Jacobson
Recombination of Excess Carriers at Twin Structures in Germanium	JL Appl Phys March 1961	A solution for the continuity equation is given for a one dimensional slab parallel to the large faces of the sample. Twin boundary recombination velocities are measured experimentally.	J. P. McKelvey
Residual Thermoelastic Stresses	JL Appl Phys March 1961	Thermoelectric stresses in bonded silicon wafers are studied by photoelastic techniques using near infrared radiation and an image converter tube.	T. D. Riney
Zone Leveling and Crystal Growth of Peritectic Compounds	JL Appl Phys March 1961	Homogeneous samples of peritectic semiconductors are prepared by combining zone leveling techniques with Bridgeman crystal growth methods.	D. R. Mason J. Stanly Cook
Photoconductivity of CdS-Type Photoconductors in the Vicinity of the Absorption Edge	JL Appl Phys March 1961	An electronic model is described in which photocurrent in photoconductors arises by excitation of electrons from discrete levels close to the valence band. Trapped holes fall to a stable ground state.	N. N. Winogradoff
Detailed Balance Limit of Efficiency of P-N Junction Solar Cells.	JL Appl Phys March 1961	Calculation of maximum and partial efficiencies of p-n junction solar energy converters is calculated for the case of radiative electron hole recombination.	W. Shockley H. J. Queisser
The Relative Magnitude of Modulation Products in Rectifier Modulators and Some Effects of Feedback	JL British IRE March 1961	The various modulation products occurring in series, shunt, and ring modulators are evaluated for square-wave switching of the rectifiers.	D. P. Howson
Parametric Amplifiers—Design and Fabrication	JL British IRE March 1961	Discussion of diode characteristics, device design, series resistance, relationship between fc and other parameters, fabrication, and encapsulation.	D. B. Day
Capillary Alloying: An Improved Alloying Method	JL Electrochem Soc March 1961	Alloying of metals in semiconductors is studied by using a liquid alloy contained in a capillary and fed from a large reservoir of alloy. The alloying method described permits the preparation of uniformly alloyed small contacts to semiconductors. Extremely flat junctions can be prepared, and the distance of these junctions from the wafer surface can be controlled at as shallow a depth as 0.25u.	K. Lehovec et al

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Photovoltages in Silicon and Germanium Layers	JL Electrochem Soc March 1961	Photovoltages up to a few hundred volts at room temperature and up to a few thousand at liquid nitrogen temperatures were observed under strong illumination in silicon and germanium layers with a distance of about 1 cm between electrodes.	H. Kallman et al
The Preparation and Floating Zone Processing of Gallium Phosphide	JL Electrochem Soc March 1961	A procedure is described for producing large solid multicrystalline ingots of gallium phosphide. Bars cut from these ingots are being employed in the investigation of the floating zone technique for growing single crystals under controlled conditions.	C. J. Frosch L. Derick
Anisotropic Segregation in InSb	JL Electrochem Soc March 1961	The anisotropic segregation of Se in InSb has been studied using radioactive Se as a tracer element. A core consisting of a high concentration of Se has been found in the center of crystals pulled in the (111) direction.	W. P. Allred R. T. Bate
A study of Growth Processes in Germanium Dendrites Using Pulse Electroplating Techniques	JL Electrochem Soc March 1961	Pulse electroplating is shown to reveal resistivity variations in germanium dentrites. The evaluation of the edges of the dendrites is deduced from the configuration of the resistivity variations.	R. C. Smith
A Transistor Oscillator Having Output Frequency Proportional to the D.C. Supply Voltage.	JL Elecnc & Control March 1961	This paper discusses a modified transistor beta-phase-shift oscillator, and deduces the conditions under which the frequency may be made to vary linearly with supply voltage.	A. R. Saha
Thermal Transient Effects on Junction Transistors	JL Elecnc & Control March 1961	Experimental evidence is presented to show that the collector leakage current I_{co} of junction transistors contains a component which does not respond immediately to a step charge in temperature, but subsequently undergoes a slow growth both for positive and negative temperature changes.	T. C. Verster
Thermal Conversion of Germanium	JL Elecnc & Control March 1961	A survey is given of the thermal conversion phenomenon. A method is described that is generally applicable to get rid of thermal conversion after heat treatment of germanium, e.g. in diffusion experiments.	W. Albers
A High Q Tuned Circuit Using a Solid State Inductance	JL Elecnc & Control March 1961	The inductance and negative resistance of a double-base diode are used to construct a frequency rejection filter with unusual properties.	I. Ladany R. J. Kearney
The Optical Properties of Cadmium Telluride in the Far Infrared Region	JL Phys Soc Japan March 1961	The reflection spectra of CdTe were measured in the spectral region from 20 u up to about 400 u at 90° K and and 300° K.	A. Mitsuishi
Regrowth of Germanium Single Crystal from Indium Melt	JL Phys Soc Japan March 1961	A crystal of n-type germanium was heated with a small piece of indium on it, and subsequently cooled rapidly to cause regrowth of the p-type germanium on the subtract germanium from the indium melt.	M. Tomono
Magnetic Properties of Intermetallic Compounds in Iron-Germanium System: $Fe_{1.07}Ge$ and $FeGe_2$	JL Phys Soc Japan March 1961	The magnetic properties of the two intermetallic compounds in the Fe-Ge system were investigated. Brief discussions on the magnetic structure are given.	K. Yasukochi K. Kanematsu
Transistor I-F Amplifier Using Double-Tuned Coupling Transformers	Mullard Tech Comm March 1961	The design of a two-stage 470 kc i-f amplifier using OC45 transistors and double-tuned transformers is described.	D. L. Jones
D-C Inverter for Fluorescent Lamps	Mullard Tech Comm March 1961	A square-wave d-c inverter is described which is suitable for driving one or two 40-watt fluorescent lamps from a 28-volt supply.	J. R. Nowicki
High Speed Logic Circuits Using Diode Logical Networks and Current-Switching Amplifiers	Mullard Tech Comm March 1961	Practical examples are given and their performance and design considerations discussed.	R. J. Miles
Output Coupling Networks for Use with Logical Circuits of the Emitter Current Switching Type	Mullard Tech Comm March 1961	Suitable networks are discussed, with emphasis on Zener-diode coupling with catching diodes to define the output signal amplitude.	R. J. Miles
Solid State Research at Low Temperatures—I Introduction	Philips Tech Rev Mar 14 1961	Part I of a three part series. Begins by way of an introduction to the subject by considering what exactly is meant by low temperature.	J. Volger
Method of Producing Stable Transistors	Philips Tech Rev Mar 14 1961	Describes some results of investigations concerning methods of achieving surface conditions that would result in good transistors with a high degree of stability.	J. J. A. Ploos van Amstel
Effect of a Constant Electric Field on Germanium Fast Surface States	Physical Review Mar 1 1961	Measurements of surface recombination velocity and surface conductivity were performed before and after application of the d-c fields of about 2×10^6 volts/cm. Results indicate that the energy and ratio of capture cross sections were unaffected by the field.	Y. Margoninski
Low-Temperature Conductivity of Additively Colored KC1	Physical Review Mar 1 1961	The transient conductivity of additively colored crystals of KC1 has been investigated at temperatures down to 10° Kelvin.	R. L. Wild F. C. Brown
Diffusion of Compound Semiconductors	Physical Review Mar 1 1961	Self-diffusion in single crystal InP and GaAs has been measured, together with the diffusion of the acceptors Cd and Zn, and the donors S and Se in GaAs.	B. Goldstein
Susceptibilities and Negative Knight Shifts of Intermetallic Compounds	Physical Review Mar 1 1961	A simple model is offered which uses the exchange polarization mechanism to relate the sign and temperature dependence of the vanadium shift, Kv, and the X-site shift, Kx, to the temperature dependent susceptibility.	A. M. Clogston V. Jacarino
Nuclear Quadrupole Absorption in Indium Metal	Physical Review Mar 15 1961	The nuclear quadrupole resonance spectrum of indium metal has been observed and studied over the temperature range 4°K to 225°K.	W. W. Simmons C. P. Slichter
Behavior of Excited Electrons and Holes in Zinc Sulfide Phosphors	Physical Review Mar 15 1961	The liminescent properties of silver and copper activated ZnS phosphors have been investigated at room and liquid air temperatures using uv, blue light, and β-ray excitation.	S. Shronoya H. P. Kallman B. Kramer

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
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Effects of Electrons and Holes on the Transition Layer Characteristics of Linearly Graded P-N Uunctions	Proc IRE March 1961	The d-c theory of p-n junctions has been extended, taking into account the mobile carriers or electrons and holes in the transition region. It is found that both the transition layer width and the transition carrier capacitance associated with the electrons and holes in the transition region increase exponentially with applied voltage under forward bias condition.	C. T. Sak
Large-Area Thin-Film Photovoltaic Cells	RCA Review March 1961	The spectral response and current voltage characteristics of a typical thin-film cell are given and compared to the same characteristic obtained from a single crystal cadmium sulfide photovoltaic cell.	H. I. Moss
Spectral Response of Photovoltaic Cells	RCA Review March 1961	A theoretical and experimental study of the spectral response of p-n junction photovoltaic cells.	J. J. Loferski J. J. Wysocki
Effect of Series Resistance on Photovoltaic Solar Energy Conversion	RCA Review March 1961	Each of these components, contact and sheet resistance is examined theoretically and experimentally, and qualitative agreement between theory and experiment is shown.	J. J. Wysocki
Considerations of Photoemissive Energy Converters	RCA Review March 1961	The efficiency of a solar energy converter consisting of a (Cs) Na_2KSb emitter and an Ag-O-Cs collector is calculated, taking into account the initial velocities of the photoelectrons, but ignoring space charge.	W. E. Spicer
Semiconductor Materials for Thermoelectric Power Generation	RCA Review March 1961	A large number of ternary compound semiconductors having the cubic structure were synthesized, and the characteristics studied.	F. D. Rosi E. F. Hocking N. E. Lindenblad
Recent Advances in High-Vacuum Techniques	Res Lab Bull (GE) Spring 1961	Brief survey of advances include vacuum pumps, measurement of vacuum, ionization gauges, and high vacuum mass spectrometry.	No Author
Device for Evaporating Multiple Films	Rev Scient Instmnts March 1961	A description is given of the construction and operation of a device which is capable of producing multiple layers of evaporated films.	G. M. Androes R. H. Hammond W. D. Knight
Measurement of Tunnell Diode Negative Resistance	Rev Scient Instmnts March 1961	Several methods for the measurement of r_j, the magnitude of the tunnel diode negative resistance, are presented.	C. C. Todd
A High Speed Analog to Digital Converter	Semiconductor Prods March 1961	A complete analog to digital converter system capable of describing a given input voltage within 25 microseconds is described in detail.	C. D. Todd
Electrical Variable Time Delay Using Cascaded Drift Transistors	Semiconductor Prods March 1961	Measuring factor, that is, cut-off frequency times a delay, is a function of a transistor with drift field in the base region. With cascaded stages, a net gain in $f_{co}\tau$ of the cascaded unit is obtained. The net gain is tabulated as a function of number of stages.	R. W. Ahrons
Electrical Representation of the Drift Transistors	Semiconductor Prods March 1961	An electrical analogue is found which is a distributed electrical system or transmission line. The analogue is developed in general form such that, for zero drift field, it becomes the well-known diffusion transistor analogue.	J. Lindmayer C. Wrigley
Complementary Resistor Transistor Logic Circuits	Semiconductor Prods March 1961	The complementary characteristic of these two types of *RTL* circuits are expressed in terms of Boolean algebra, which shows that different types are more suitable for handling OR-AND and AND-OR logic.	S. C. Chao
An Equipment for High Power Rectifier Evaluation	Semiconductor Prods March 1961	The difficulties encountered using simple test methods are discussed, and one of the solutions to this problem is given.	G. Randolph
The Use of Silicon Junction Diodes for the Protection of A-C and D-C Meter Circuits	Semiconductor Prods March 1961	The application of the nonlinear characteristics of a silicon junction diode, operating in its forward or Zener region, to the protection of a-c and d-c meter circuits is described.	P. G. Ducker
The Design of Distributed Amplifiers Using Silicon Double Diffused Transistors	Solid State JL March 1961	A new scheme is proposed in which the base current increases with frequency at the same rate that the current gain falls with frequency, i.e. at approximately 6 db per octave.	P. J. Beneteau L. Blaser
Epitaxial Techniques in Semiconductor Devices	Solid State JL March 1961	Junction formation, epitaxial deposition, devices fabricated by epitaxial deposition, and transistor characteristics.	J. Sigler S. B. Watelski
Bridgeman Effect in Bismuth Telluride Crystals	Sov Phys Solid State Feb 1961	An investigation of the thermoelectric emf associated with a temperature gradient impressed across adjacent monocrystalline areas having different orientations.	P. I. Baranskii S. L. Tomkevich
On p-n Junctions in Photosensitive Films of PbS	Sov Phys Solid State Feb 1961	The existence of p-n-p junctions in PbS films sensitized by high temperature activation in air is demonstrated.	V. F. Zolotarev V. N. Larichev
Photoelectric Converter Made of Polycrystalline Silicon	Sov Phys Solid State Feb 1961	In solar energy photoelectric converters made of polycrystalline silicon the current maximum power which has been achieved is 6 mw/cm^2. The cost of using polycrystalline silicon is considerably less than that of using the monocrystalline material.	A. Y. Gliberman A. K. Zaitseva A. P. Landsman
Recombination of Electrons and Holes in Atoms of Copper and Nickel in High Resistance Germanium	Sov Phys Solid State Feb 1961	The lifetime for samples having a nickel impurity decreases exponentially with temperature at an activation energy of 0.5 ev while the lifetime of samples having a copper impurity increases exponentially when $\Delta E = .07$ ev.	V. V. Rybalka A. S. Pizio
Concerning the Investigation of the Photoconductivity of Powdered Semiconductors by the Photoelectric Effect Method	Sov Phys Solid State Feb 1961	A method for studying photoconductive properties of semiconductor powders dispersed in a dielectric.	Y. A. Oksman A. V. Burlyakov
Role of Trapping Centers in the Relaxation of Photoconductivity	Sov Phys Solid State Feb 1961	The decay of photoconductivity without assuming negligible filling of trapping centers is investigated.	I. I. Boiko

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Problem of the Interaction Between Copper and Antimony in Germanium	Sov Phys Solid State Feb 1961	At temperatures below 600°C, chemical interaction between Cu and Sb can occur when they are both present in Ge single crystals at concentrations lower than the solubility limit.	A. Y. Potemkin V. I. Potapov
Concerning Laws Governing Field Emission in Semiconductors	Sov Phys Solid State Feb 1961	Temperature dependence of the field emission current is determined by an increased electron concentration in the surface layer of semiconductors due to penetration of the field.	A. I. Klimin B. N. Sedykh I. L. Sokol'skaya
The Electrical Conductivity of Evaporated Germanium Layers	Sov Phys Solid State Feb 1961	A study of conductivity, structure, and optical absorption of evaporated thin germanium films.	P. P. Konorov O. V. Romanov
The Properties of Semiconductors with Extremal Loops. II Magnetic Susceptibility in a Field Perpendicular to the Plane of the Loop	Sov Phys Solid State Feb 1961	A presentation of a theory of magnetic susceptibility for semiconductors with extremal loops.	I. I. Boiko E. I. Rashba
Photodielectric Properties of Polycrystalline Cadmium Selenide I. High Temperatures	Sov Phys Solid State Feb 1961	In the temperature range 20°C to 108°C, at frequencies below 200kc, the photodielectric effect in powdered cadmium selenide is shown to be due to noncomplex photoconductivity.	Y. A. Oksman A. V. Burlyakov
Induced Infrared Photosensitivity in Certain Semiconductors	Sov Phys Solid State Feb 1961	Induced infrared photosensitivity due to structural defects in the crystal lattice is exhibited by several semiconductors such as CdSe, CdTe, and Sb_2Se_3.	E. N. Arkadeva S. M. Rivkin
Photoelectric Properties of Alloy p-n Junctions in Silicon Carbide	Sov Phys Solid State Feb 1961	The spectral and total photovoltaic response characteristics of alloy p-n junctions in alpha type silicon are discussed.	G. F. Kholuyanov
The Effect of a Strong Electric Field on the Absorption of Light by Silicon	Sov Phys Solid State Feb 1961	In silicon subjected to electric field strengths of $5\text{-}10^4$ v/cm a shift towards longer wavelengths of 150 angstom units in the fundamental absorption edge is observed.	V. S. Vavilov K. I. Britsyn
The Electrical Conductivity of Germanium at Low Temperatures	Sov Phys Solid State Feb 1961	In the absence of thermal radiation, the resistivity and Hall constant of germanium obey an exponential law with an activation energy of .01 ev.	S. G. Kalashnikov I. A. Kurova
The Effective Carrier Mass in Lead Selenide	Sov Phys Solid State Feb 1961	Consideration is given to the manner in which forbidden band width varies with changes in effective electron and hole masses.	I. A. Smirnov B. Y. Moizhes E. D. Devyatkova
Emission Properties of Silicon Treated in Cesium Vapors	Sov Phys Solid State Feb 1961	A study of thermionic, photoelectric, and secondary electron emission of silicon single crystals and silicon films treated in cesium vapors.	V. G. Bol'shov L. V. Vasil'eva G. N. Pautova
Determination of the Recombination Constant and the Depth of a p-n Junction from the Spectral Characteristics of a Photocell	Sov Phys Solid State Feb 1961	A method is presented which utilizes the relationship between photocell short circuit current and the optical absorption coefficient of the cell.	V. K. Subashiev G. B. Dubrovskii V. A. Petrusevich
Forward Current-Voltage Characteristics of a Barrier Layer in a Germanium p-n Junction	Sov Phys Solid State Feb 1961	The characteristic obtained for alloyed germanium p-n junctions confirms Shockley's formula at current densities from 0.1 to 100 amp/cm² in the temperature range from —77°C to 70°C.	F. M. Berkovskii S. M. Ryvkin M. B. Strokan
The Influence of Trap Levels on the Relaxation of the Non-equilibrium Conductivity of Germanium Irradiated with Gamma Rays	Sov Phys Solid State Feb 1961	A discussion of the mechanics of the recombination process connected with defects produced by gamma rays.	S. M. Ryvkin I. D. Yaroshetskii
Investigation of the Barrier Capacitance of Diffused p-n Junctions In Silicon	Sov Phys Solid State Feb 1961	The effects of voltage and temperature upon barrier capacitance are discussed and an equation approximating the voltage dependence of said capacitance is given.	L. S. Berman V. K. Subashiev
Switching Microwave Energy with Semiconductor Diodes	Sperry Engg Review March 1961	Problems in r-f switching are outlined and the use of diodes as effective wideband switches is described.	R. L. Michal
Neutron Irradiation Effects on Minority Carrier Lifetime in Silicon Diodes.	US Govt Res Repts March 1961 LC $4.80 NYO-7396	No abstract.	B. Wickesberg
Switching and Memory Criteria In Transistor Flip-Flop	US Govt Res Repts March 1961 LC $4.80 PB147313	A study is made of the relationship between the characteristics of the trigger pulse and the switching and memory capabilities of the flip-flop.	D. K. Lynn D. O. Pederson
Thin Film Circuit Functions	US Govt Res Repts March 1961 LC $18.30 PB152672	The technology of preparing six specific types of thin film circuits is described in detail.	W. N. Carroll R. G. Counihan
Solid State Display Panels With Photoconductive Control	US Govt Res Repts March 1961 LC $4.80 PB152409	A theory concerning the operation of solid state display panels is described.	R. R. Billups J. Rothstein
Intrinsic-Barrier Transistor Techniques (Silicon)	US Govt Res Repts March 1961 LC $4.80 PB152659	Photo-resist techniques used in processing silicon mesa transistors are described.	J. L. Buie M. Millea R. C. Neville
Dielectric Constant of Germanium and Silicon as a Function of Volume	US Govt Res Repts March 1961 LC $21.30 PB149628	The pressure and temperature dependence of the dielectric properties of silicon and germanium are investigated.	M. Cardona
Investigation of Composite or Stacked Variable Energy Gap Photovoltaic Solar Energy Converter.	US Govt Res Repts March 1961 LC $7.80 PB149706	A discussion performance of a composite photovoltaic solar cell, which consists of two separate cells with different energy gaps.	J. W. Burns W. Evans H. Armstrong
Solid State Research	US Govt Res Repts March 1961 LC $16.80 PB152462	A progress report on device design, materials research, components.	Lincoln Lab MIT
Transmission Line Formulation for Semiconductors	US Govt Res Repts March 1961 LC $3.30 PR149679	Plane wave scattering from a crystal plane is discussed.	H. Kurss

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from July 7, 1959 to July 28, 1959. In subsequent issues, patents issued from July 28, 1959 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.

July 7, 1959

2,893,850 Apparatus For The Production of Elemental Silicon—F. Von Bichowsky. Assignee: None. A means for controlling the deposition of silicon upon hot metal plates within a reaction chamber, said plates then undergoing thermal expantion which facilitates removal of the silicon.

2,893,904 Thermal Zener Device On The Like—D. C. Dickson Jr. Assignee: Hoffman Electronics. A junction device wherein high reverse currents cause operation at the thermal breakdown voltage level rather than the Zener voltage level, said device being suitable for use as a short circuit switch or protective element.

2,893,929 Method For Electroplating Selected Regions of N-Type Semiconductive Bodies—G. L. Schnable. Assignee: Philco Corp. Means for electroplating n-type areas of a transistor without plating the emitter or collector of the device.

2,894,075 Telephone Set—H. Kunckel. Assignee: None. A portable telephone set including microphone and a single stage transistor amplifier which also operates as an audio frequency ringer.

2,894.112 Apparatus For Attaching Leads To Crystals—R. S. Breska, R. L. Moore, H. W. Schaufelberger. Assignee: Western Electric Co. Means for locating and affixing headed ends of wire leads surrounded with solder to crystals or the like.

2,894,126 Radio Frequency Amplifier and Converter—T. B. Horgan. Assignee: AVCO Mfg. Corp. A transistorized high gain high frequency amplifier and converter for use in a superheterodyne radio receiver.

2,894,150 Transistor Signal Translating Circuit—C. C. Bopp. Assignee: AVCO Mfg. Corp. A signal amplitude limiter utilizing, jointly, emitter bias variation induced by signal level changes, and collector voltage saturation, as response limiting mechanisms for a transistor.

2,894,152 Crystal Diode With Improved Recovery Time—R. L. Anderson. Assignee: IBM. Point contact diodes and gold bonded junction diodes having fast pulse recovery times, in the order of 0.31 to 2.8 micro-seconds, depending on bias voltage.

2,894,180 Transistor Saturable Reactor Relay With Over-Frequency Cutout—R. J. Price. Assignee: None: A trigger controlled relay which ceases to operate when the control pulse frequency reaches a predetermined value.

2,894,183 Transistor Subassembly—A. Fermanian. Assignee: Sprague Electric Co. A contact electrode subassembly suitable for use with both point contact and junction devices.

2,894,184 Electrical Characteristics of Diodes—C. W. Veach, R. L. Crone. Assignee: Hughes Aircraft Co. Means for increasing the travel distance of minority carriers comprising the reverse leakage current, thereby reducing said current.

2.894.206 Transistor Beta Tester—G. F. Montgomery. Assignee: USA (Commerce Dept.). An instrument for measuring the short circuit grounded emitter current amplification (beta) of a junction transistor, at audio frequencies.

2,894,208 Frequency Shift Transmitter—R. P. Crow. Assignee: Motorola Inc. A 40 KC to 200 KC frequency shift transmitter utilizing a channel for transmitting information, said channel having a bandwidth of 500 cycles.

2,894,210 Magnetic Coupled Multivibrator —T. Erb. Assignee: Sperry Rand Corp. A self exciting magnetic coupled multivibrator circuit employing a saturable core device to provide frequency control.

2,894,211 Stable Transistor Oscillator System—E. J. Bussard. Assignee: AVCO Mfg. Corp. A dominant positive feedback oscillator system including means for automatic self adjustment of the transistor to achieve optimum operating conditions for the circuit concerned.

2,894,215 Linear Voltage - To - Frequency Converter—W. N. Toy. Assignee: BTL. A multivabrator wherein the frequency of operation can be varied linearly over an extended range with respect to the amplitude of a control signal.

2,894,217 Computing Circuits—J. G. Linvill. Assignee: BTL. A low distortion circuit in which a negative impedance converter is employed to obtain zero impedance across the output element (as seen by the source).

2,894,234 Electric Variable Resistance Devices—H. Weiss, H. Welker. Assignee: Siemens Schuckertwerke. A. G. (Germany). A device employing a semiconductor element shaped and predisposed so that current flow there-through is dependent upon the strength of the magnetic field in which the element is placed.

2,894,246 Fire Alarm System—A. L. De Graffenried. Assignee: R. J. Stockholm, et al. A transistorized system for indicating the presence of abnormal conditions of temperature pressure or structure in vehicle wheels.

2,894,250 Variable Frequency Magnetic Multivibrator—R. W. Rochelle, R. L. Van Allen. Assignee: None. An information storage circuit which provides storage of peak current information and nondestructive readout thereof.

July 14, 1959

2,894,313 Method and Apparatus For The Controlled Aging of Semiconductor Devices—J. W. Stinman, S. A. Robinson. Assignee: Philco Corp. An aging process comprising treatment of semiconductor devices with voltage pulses of increasing magnitude.

2,894,314 Method of Making Selenium Rectifier—J. C. van Vessem. Assignee: North American Philips Co. A method including thermal treatment prior to forming, which treatment yields a selenium-cadmium compound on the counter electrode.

2,894,862 Method of Fabricating P-N Type Junction Devices—C. W. Mueller. Asignee: RCA. A process which includes etching a semiconductor device after formation of the p-n junction in order to prevent diffusion or evaporation of impurity substances over the surface of the device.

2,894,863 Production of Semiconductor Bodies—S. E. Bradshaw, H. Weald, A. I. Mlavsky. Asignee: Gen. Electric Co. Ltd. A technique employing progressive solidification of a body of molten silicon, and formation of p-type and n-type regions therein by selective evaporation from portions thereof of previously incorporated antimony.

2,895,045 Radio Receiver With Transistorized Audio Detector and Automatic Gain Control Circuitry—S. Kagan. Assignee: AVCO Mfg. In a receiver of the type described, a common emitter detector stage in cascade with an emitter-follower audio amplifier stage.

2,895,058 Semiconductor Devices And Systems—J. I. Pankove. Assignee: RCA.

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

Means for achieving phase inversion between output and input signals.

2,895,081 Interrupted Flash Generator—J. W. Crownover, N. R. Smith. Assignee: None. A transistorized system for actuating a flasher such as a warning light.

2,895,095 Electronic D.C. Motor—J. H. Guyton. Assignee: General Motors Corp. A contactless transistorized small d-c motor.

2,895,100 Semiconductor Junction Type Rectifier Systems—L. Filberich, H. Nagorsen. Assignee: Siemens Schuckertwerke AG. Means for suppressing the reverse leakage current in semiconductor diodes.

2,895,109 Negative Resistance Semiconductive Element—G. Weinreich. Assignee: BTL. Means for increasing the frequency range of operation of the semiconductive device, and means for causing amplitude or frequency modulation of an oscillator circuit containing said device.

July 21, 1959

2,895,673 Transistor Binary Adder—F. C. Williams. Assignee: National Research Development Corp. (England). An adding circuit for producing sum and carry binary digit output signals in response to analogue input signals.

2,895,797 Recovery of Germanium Tetrachlodire—C. T. Hill. Assignee: Texas Gulf Sulphur Company. Treatment of germanium sulphide with chlorine at 300° C to 400° C in the presence of liquid sulphur yields sulphur and germanium tetrachloride.

2,896,029 Semiconductor Amplifier Circuits—H. C. Lin. Assignee: RCA. A transistorized push-pull single-ended amplifier.

2,896,068 Electronic Track Circuit for Railroads—J. H. Auer, Jr., C. S. Wilcox, M. E. Hoff, Jr. Assignee: General Railway Signal Co. A railroad vehicle detection circuit.

2,896,114 Television Deflection and Power Supply Circuits—I. G. Maloff. Assignee: RCA. Transistor horizontal deflection and high voltage power supply circuits reduce ringing in the deflection circuit.

2,896,115 Retrace Driven Deflection Circuit for Cathode Ray Tubes—W. B. Guggi. Assignee: RCA. A deflection circuit having means for adjusting the sweep amplitude without affecting the linearity of the circuit.

2,896,124 Gaseous Glow Tube Circuits—L. R. Brown. Assignee: Burroughs Corp. Means for converting low voltage d-c to high voltage d-c for the operation of a gaseous glow tube.

2,896,126 Lightning Protection for an Electronic Track Circuit—M. E. Hoff, Jr. Assignee: General Railway Signal Co. A system for protecting low voltage electronic devices from damaging large amplitude transient voltage surges, including capacitive means for dissipating the excess energy.

2,896,130 Transistor Actuated Device—H. E. Tompkins. Assignee: Burroughs Corp. A high speed solenoid actuation and release mechanism.

2,896,134 Loop Contact for Semiconductor—J. H. Myer. Assignee: Hughes Aircraft Co. A crystal-to-electrode contact consisting of a loop of a thin convex-shaped metallic ribbon which is pressed into contact with a crystal within the confines of a tubular-shaped element.

2,896,136 Semiconductor Units—K. R. Hales. Assignee: Philco Corp. A hermetically sealed power transistor.

2,896,146 Oscillator Starting Circuit—R. L. Jenkins. Assignee: General Motors Corp. A transistorized circuit for starting an oscillator which is in turn used to energize a vacuum tube rectifier.

2,896,149 Electrical Generator Control Apparatus—L. R. Lowry Jr., G. W. Ernsberger. Assignee: Westinghouse Electric Corp. A regulator system for controlling the excitation current applied to the field of a generator.

2,896,150 Frequency Control Device for Generators—B. M. Benton, R. P. Judkins. Assignee: Boeing Airplane Co. A transistor circuit for exciting the field of an a-c generator whereby the generator produces a constant frequency output.

2,896,151 Semiconductor Apparatus—R. J. Zelinka. Assignee: Minneapolis-Honeywell Regulator Co. A power supply voltage regulator including a tetrode transistor utilized as the final regulation stage.

2,896,168 Transistor Characteristic Curve Tracers—Assignee: BTL. Means for measuring transistor parameters under stable conditions, including a collector constant voltage bias supply and an emitter constant current bias supply.

2,896,170 Oscillator Circuit for Transistors—T. Grewe. Assignee: International Standard Electric Corp. A limiter for a transistor oscillator whereby pulse shifts resulting from changing loads are minimized.

2,896,171 Oscillator—L. W. Erath. Assignee: Dresser Industries, Inc. A variable frequency oscillator comprising a p-n-p transistor coupled to a vacuum tube, said circuit having an output frequency variable between 1 cps and 2 megacycles.

July 28, 1959

2,896,305 Rectifier Electroforming Process—G. Eannarino. Assignee: Sarkes Tarzian Inc. Selenium rectifier plates are electroformed at 1 to 3 amperes per square inch in an oil bath maintained at a temperature below 40° C.

2,897,105 Formation of P-N Junctions—L. P. Hunter. Assignee: International Business Machines Corp. P-N junction devices are formed by the controlled melting of semiconductor material in powder form.

2,897,283 Multi Office Interlocked Signalling Telephone System—J. G. Pearce, M. P. Tubinis. Assignee: General Dynamics Corp. Means for accurate transmission and utilization of line selecting information.

2,897,295 Cascaded Tetrode Transistor Amplifier—R. J. Zelinka. Assignee: Minneapolis-Honeywell Regulator Co. A composite type tetrode transistor amplifier.

2,897,329 Zone Melting Apparatus—H. F. Matare. Assignee: Sylvania Electric Products Inc. Production of semiconductor material using a floating zone technique.

2,897,353 Non-Linear Device Varying Impedance Match Between Antenna and Radio Frequency Stages—W. W. Schweiss. Assignee: Philco Corp. A Class A transistor amplifier suitable for use in the r-f stage of a radio receiver.

2,897,377 Semiconductor Surface Treatments and Devices Made Thereby—H. Nelson, Arnold Moore. Assignee: RCA. Surface recombination in semiconductor devices is inhibited by layers of strong acid salts, electropositive metals, and aromatic organic materials placed in contact with the surfaces of said devices.

2,897,378 Semi-Conductor Signal Translating Circuits—J. P. Jones, Jr. Assignee: Navigation Computer Corp. A high frequency response circuit.

2,897,379 Transistor Phase Discriminator—J. G. Hinsdale. Assignee: Lear Inc. A discriminator circuit employing split load impedances wherein the outputs across the dual loads are controlled by a single transistor.

2,897,380 Magnetic Pulse Counting and Forming Circuits—C. Neitzert. Assignee: General Time Corp. Common emitter connected transistors are utilized to automatically reset saturable core devices in a magnetic pulse counter.

3,897,419 Semiconductor Diode—F. L. Howland and J. W. West. Assignee: BTL. A miniature junction diode suitable for use in printed circuits.

2,897,421 Phototransistor Design—A. P. Kruper. Assignee: Westinghouse Electric Corp. A device which presents a large area photosensitive junction and a high ratio of effective photosensitive material to semiconductor volume.

2,897,429 Supply Circuit Transistor Current Control For Electric Loads—P. J. Jochems. Assignee: North American Philips Company, Inc. A current supply circuit, the output of which is independent of supply voltage or load impedance.

2,897,430 Stabilized Transistor Electrical Power Supply—J. T. Winkel. Assignee: North American Philips Company, Inc. A power supply which provides a stabilized direct voltage across a load.

2,897,431 Voltage Stabilizing Circuit—E. Wolfendale. Assignee: North American Philips Co. Inc. Transistor voltage stabilizing circuit for a d-c power supply

2,897,432 Electrical Signal Regulator—J. M. Jackson. Assignee: General Electric Company. A load voltage regulator including a transistor voltage comparator for producing an output in response to load voltage variations, said output being used to effect a compensating change in load impedance.

2,897,433 Direct Current Voltage Regulator—R. P. Putkovich, G. J. Thompson. Assignee: Westinghouse Electric Corp. A d-c voltage regulator using transistor controlled magnetic amplifiers to provide an output voltage which varies inversely with a control voltage, the sum of the two being maintained at a constant predetermined value.

(To be Continued)

MANUFACTURERS
(In Order of Code Letters)

ARA— Advanced Research Associates, Inc.
AEG— Allgemeine Elecktricitats-gesellschaft
AMP— Amperex Electronic Corp.
AEIE— Associated Electrical Industries Ediswan Div.
AEIL— Associated Electrical Industries Export
ATLB— Associated Transistors Ltd.
BEN— Bendix Corp.
CBS— CBS Electronics
CDLF— Compagnie des Lampes
CSF— Compagnie Generale
CRY— Crystalonics, Inc.
CTP— Clevite Transistor Products, Inc.
DEL— Delco Radio Div., General Motors Corp.
ELE— Electromation Co.
ETC— Electronic Transistor Corp.
FSC— Fairchild Semiconductor Corp.
FTC— Fannon Transistor Corporation
FTHF— French Thompson-Houston Semiconductor Dept.
FCAJ— Fuji Communication Apparatus Manufacturing Co.
GECB— General Electric Co., Ltd.
GE— General Electric Co.
GIC— General Instrument Corp.
GEM— Great Eastern Mfg. Co.
HITJ— Hitachi Ltd., Mushashi Works
HIVB— Hivac Ltd.
HSD— Hoffman Semiconductor Div.
HUG— Hughes Aircraft Co.
IND— Industro Transistor Corp.
INTG— Intermetall
KSC— Kearfott Semiconductor Corp.
KOKJ— Kobe Kogyo Corp.
LCTF— Labortoire Central de Telecommunications
MIN— Minneapolis-Honeywell Regulator Co.
MISI— Mistral
MOT— Motorola, Inc.
MUL— Mullard Ltd.
NAC— National Semiconductor Corp.
NTLB— Newmarket Transistors Ltd.
NECJ— Nippon Electric Co. Ltd.
PSI— Pacific Semiconductors. Inc.
PHI— Philco Corp., Lansdale Division, Semiconductor Operations
PHIN— N. V. Philips Gloeilampen-Fabrieken
RAY— Raytheon Co.
RCA— Radio Corp. of America, Semiconductor Div.
RDR— Radio Development and Research
RADF— La Radiotechnique, Div. Tubes Electroniques
RHE— Rheem Semiconductor Corp.
ROSG— Dr. ing. Rudolph Rost
SANJ— Sanyo Electric Co. Ltd.
SEC— Secoa Electronics Corporation
SIE— Siemens & Halske Aktiengesellschaft
SIL— Silicon Transistor Corp.
SGSI— Societa General Semiconduttori
SONY— Sony Corp.
SPE— Sperry Rand Corporation
SPR— Sprague Electric Co.
STCB— Standard Telephone & Cables, Ltd.
STCA— Standard Telephones and Cables Pty, Ltd.
TKAD— Suddeutsche Telefon-Apparate-, Kabel und Drahtwerke
SYL— Sylvania Electric Products Inc.
TOSJ— Tokyo Shibaura Electric Co.
TRA— Transitron Electronic Corp.
TFKG— Telefunken Ltd.
TI— Texas Instruments Incorporated
TIIB— Texas Instruments Ltd.
TUN— Tung-Sol Electric, Inc.
UST— U. S. Transistor Corp.
WEC— Western Electric Co., Inc.
WTC— Western Transistor Corp.
WEST— Westinghouse Electric Corp.

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C.				Typical Characteristics			MFR. See Code
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	
2N428A	2,5	PNPA	Ge	150	.50	30	18	12	h_{FE}:I_E-1.0ma	100	GIC
2N698	2,4,5Ø	NPNPL	Si	3.0W	58.3Ø	120	80	70†	h_{FE}:I_C-150ma	50Ø	FSC
2N699B	2,3,4,5	NPNPL	Si	5.0W	35Ø	120	100	120†	h_{FE}:I_C-150ma	70Ø	FSC
2N707A	2	NPNMe	Si	300	500	70		500†	h_{FE}:I_C- 10ma	30	MOT
2N709	2,4,5	NPNPL	Si	1.0W	175Ø	12	5.0	800†	h_{FE}:I_C- 10ma	50Ø	FSC
2N722	2,4,5	PNPD	Si	1.5W	83.3Ø	50	50	90†	h_{FE}:I_C-150ma	50Ø	FSC
2N741A	2	PNPMe	Ge	150	500	20		360†	h_{FE}:I_E- 25ma	25	MOT
2N743	2,5	NPNE	Si	300	500	25			h_{FE}:I_C- 10ma	40	NAC
2N744	2,5	NPNE	Si	300	500	25			h_{fe}:I_C- 10ma	80	NAC
2N756A	2	NPNMe	Si	500		60		100	h_{fe}:I_e-1.0ma	17	NAC
2N757A	2	NPNMe	Si	500		60		100	h_{fe}:I_e-1.0ma	29	NAC
2N758A	2	NPNMe	Si	500		60		100	h_{fe}:I_e-1.0ma	54	NAC
2N759A	2	NPNMe	Si	500		60		100	h_{fe}:I_e-1.0ma	63	NAC
2N760A	2	NPNMe	Si	500		60		100	h_{fe}:I_e-1.0ma	204	NAC
2N780	2	NPNMe	Si	300	500		45		h_{FE}:I_C- 10ma	160max	TI
2N835	2	NPNMe	Si	300	500	25		450†	h_{FE}:I_E- 10ma	40	MOT
2N849	2,5	NPNMe	Si	450	330	25			h_{FE}:I_C- 10ma	40	TI
2N850	2,5	NPNMe	Si	450	330	25			h_{FE}:I_C- 10ma	80	TI
2N913	2,4,5	NPNPL	Si	1.2W	146Ø	25	18	350†	h_{FE}:I_C- 10ma	60Ø	FSC
2N935	5	PNPA	Si	385	.35	50	40	.20#	h_{FE}:I_B-.10ma	15	SSD
2N936	5	PNPA	Si	385	.35	50	35	.30#	h_{FE}:I_B-.10ma	30	SSD
2N937	5	PNPA	Si	385	.35	50	30	.50#	h_{FE}:I_B-.10ma	60	SSD
2N938	4	PNPA	Si	250	.60	40	35	1.0Ø	h_{fe}:I_e-1.0ma	15	SSD
2N939	4	PNPA	Si	250	.60	40	35	2.0Ø	h_{fe}:I_e-1.0ma	30	SSD
2N940	4	PNPA	Si	250	.60	40	35	2.0Ø	h_{fe}:I_e-1.0ma	60	SSD
2N941	5	PNPA	Si	250	.60	25	8.0	12Ø			SSD
2N942	5	PNPA	Si	250	.60	25	8.0	10Ø			SSD
2N943	5	PNPA	Si	250	.60	40	18	1.0Ø			SSD
2N944	5	PNPA	Si	250	.60	40	18	1.0Ø			SSD
2N945	5	PNPA	Si	250	.60	50	50	1.0Ø			SSD

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C.				Typical Characteristics			MFR. See Code
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	
2N946	5	PNPA	Si	250	.60	80	80	1.0Ø			SSD
2N956	2,4,5Ø	NPNPL	Si	1.8W	97.2Ø	75	50	120†	h_{FE}:I_C-150ma	120Ø	FSC
2N957	2,4,5	NPND	Si	.80W	156Ø	40	25	200†	h_{FE}:I_C- 10ma	65Ø	FSC
2N960	5	PNPDE	Ge	150	500	15	15	450	h_{FE}:I_C- 10ma	20min	MOT
2N961	5	PNPDE	Ge	150	500	12	12	300	h_{FE}:I_C- 10ma	20min	MOT
2N962	5	PNPDE	Ge	150	500	12	12	450	h_{FE}:I_C- 10ma	20min	MOT
2N964	5	PNPDE	Ge	150	500	15	15	450	h_{FE}:I_C- 10ma	40min	MOT
2N965	5	PNPDE	Ge	150	500	12	12	450	h_{FE}:I_C- 10ma	40min	MOT
2N966	5	PNPDE	Ge	150	500	12	12	450	h_{FE}:I_C- 10ma	40min	MOT
2N968	5	PNPD	Ge	150	500	15	15	300	h_{FE}:I_C- 10ma	17min	MOT
2N969	5	PNPD	Ge	150	500	12	12	300	h_{FE}:I_C- 10ma	17min	MOT
2N970	5	PNPD	Ge	150	500	12	12	300	h_{FE}:I_C- 10ma	17min	MOT
2N971	5	PNPD	Ge	150	500	7.0	7.0	300	h_{FE}:I_C- 10ma	17min	MOT
2N972	5	PNPD	Ge	150	500	15	15	300	h_{FE}:I_C- 10ma	40min	MOT
2N973	5	PNPD	Ge	150	500	12	12	300	h_{FE}:I_C- 10ma	40min	MOT
2N974	5	PNPD	Ge	150	500	12	12	300	h_{FE}:I_C- 10ma	40min	MOT
2N975	5	PNPD	Ge	150	500	7.0	7.0	300	h_{FE}:I_C- 10ma	50min	MOT
2N978	2,4,5	PNPD	Si	1.25W	100Ø	30	20	50†	h_{FE}:I_C-150ma	35Ø	FSC
2N1131	2,4,5Ø	PNPD	Si	2.0W	75Ø	50	50	50†	h_{FE}:I_C-150ma	30Ø	FSC
2N1132	2,4,5Ø	PNPD	Si	2.0W	75Ø	50	50	60†	h_{FE}:I_C-150ma	50Ø	FSC
2N1232A	2	PNPA	Si	400	320	90		1.0	h_{fe}:I_e-1.0ma	20	HUG
2N1242A	3	PNPA	Si	1000	140	90		1.0	h_{fe}:I_e-1.0ma	20	HUG
2N1430	3	PNPDA	Ge		1.7	100	100	1.5	h_{FE}:I_C-5.0A	75	BEN
2N1517A	2	PNP	Ge	100	600	40		70	h_{fe}:I_e-1.0ma	150	AMP
2N1616A	3,5Ø	NPND	Si	85W	2.1	80	60	1.5	h_{FE}: 2.0A	30	SIL
2N1617A	3,5Ø	NPND	Si	85W	2.1	80	70	1.5	h_{FE}: 2.0A	30	SIL
2N1618A	3,5Ø	NPND	Si	85W	2.1	100	80	1.5	h_{FE}: 2.0A	30	SIL
2N1705	2	PNP	Ge	200		18		4.0	h_{fe}:I_c-1.0ma	110	TUN
2N1706	2	PNP	Ge	200		25		3.0	h_{fe}:I_c- 10ma	90	TUN
2N1707	2	PNP	Ge	200		30		3.0	h_{fe}:I_c- 10ma	95	TUN

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C. P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics $f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	MFR. See Code
2N1711	2,4,5Ø	NPNPL	Si	3.0W	58.3Ø	75	50	120†	h_{FE}:I_C-150ma	120Ø	FSC
2N1755	3	PNPA	Ge	28W	2.5	40	30	.30	h_{FE}:I_C-.50A	53	CTP
2N1756	3	PNPA	Ge	28W	2.5	60	50	.30	h_{FE}:I_C-.50A	53	CTP
2N1757	3	PNPA	Ge	28W	2.5	80	65	.30	h_{FE}:I_C-.50A	53	CTP
2N1758	3	PNPA	Ge	28W	2.5	100	75	.30	h_{FE}:I_C-.50A	53	CTP
2N1759	3	PNPA	Ge	28W	2.5	40	35	.30	h_{FE}:I_C-.50A	105	CTP
2N1760	3	PNPA	Ge	28W	2.5	60	50	.30	h_{FE}:I_C-.50A	105	CTP
2N1761	3	PNPA	Ge	28W	2.5	80	65	.30	h_{FE}:I_C-.50A	105	CTP
2N1762	3	PNPA	Ge	28W	2.5	100	75	.30	h_{FE}:I_C-.50A	105	CTP
2N1808	2	NPNA	Ge	150	400	25		4.0	h_{FE}:I_C- 24ma	60	TI
2N1980	3	PNPA	Ge		.50	50	30	3.0Δ	h_{FE}:I_C-5.0A	75	TI
2N1981	3	PNPA	Ge		.50	70	40	3.0Δ	h_{FE}:I_C-5.0A	75	TI
2N1982	3	PNPA	Ge		.50	90	50	3.0Δ	h_{FE}:I_C-5.0A	75	TI
2N1994	2	NPNA	Ge	150	400	30		3.0	h_{FE}:I_C-200ma	20	TI
2N1995	2	NPNA	Ge	150	400	25		5.0	h_{FE}:I_C-200ma	25	TI
2N1997	2	PNPA	Ge	250	300	45		3.0	h_{FE}:I_C-100ma	75	TI
2N1998	2	PNPA	Ge	250	300	35		6.5	h_{FE}:I_C-200ma	100	TI
2N1999	2	PNPA	Ge	250	300	30		12	h_{FE}:I_C-200ma	120	TI
2N2000	2	PNPA	Ge	300	250	50		2.0	h_{FE}:I_C-500ma	150	TI
2N2001	2	PNPA	Ge	300	250	30		6.0	h_{FE}:I_C-500ma	200	TI
2N2002	2	PNP	Si	250	900	30		.80			NAC
2N2003	2	PNP	Si	250	900	30		.80			NAC
2N2004	2	PNP	Si	250	900	50		.80			NAC
2N2005	2	PNP	Si	250	900	50		.80			NAC
2N2006	2	PNP	Si	250	900	60		.80			NAC
2N2007	2	PNP	Si	250	900	60		.80			NAC
2N2015	3	NPND	Si		1.17	100	50	25Kc Δ	h_{FE}:I_C-5.0A	15min	RCA
2N2016	3	NPND	Si		1.17	130	65	25Kc Δ	h_{FE}:I_C- 10A	75min	RCA
2N2033	3,5	NPND	Si	5000	20	80	60	1.5	h_{FE}: .50A	50	SIL
2N2034	3,5	NPND	Si	5000	20	80	60	1.5	h_{FE}: 1.0A	40	SIL
2N2035	3,5	NPND	Si	25W	7.0	80	60	1.5	h_{FE}: 15A	30	SIL
2N2042	2	PNPA	Ge	200	500	105	105	.50	h_{FE}:I_C-5.0ma	35	MOT
2N2042A	2	PNPA	Ge	200				.50Ø	h_{FE}:I_E-1.0ma	50	MOT
2N2043	2	PNPA	Ge	200	500	105	105	.75	h_{FE}:I_C-5.0ma	70	MOT
2N2043A	2	PNPA	Ge	200				.75Ø	h_{FE}:I_E-1.0ma	113	MOT
2N2048	5	PNPMD	Ge	150	500	20	20	260#	h_{FE}:I_C- 10ma	125	PHI
2N2049	2,4,5Ø	NPNPL	Si	3.0W	58.3Ø	75	50	100†	h_{FE}:I_C-.10ma	120Ø	FSC
2N2059	2	PNPMD	Ge	60	800	10		50†	h_{FE}:I_C- 10ma	35	CBS
2N2061	3	PNPA	Ge	45W	1.5	20	20		PG at 2.0W	20-29db	CTP
2N2062	3	PNPA	Ge	45W	1.5	20	20		PG at 2.0W	27-37db	CTP
2N2063	3	PNPA	Ge	45W	1.5	40	35		PG at 2.0W	26-33db	CTP
2N2064	3	PNPA	Ge	45W	1.5	40	35		PG at 2.0W	32-39db	CTP
2N2065	3	PNPA	Ge	45W	1.5	80	65		PG at 2.0W	26-33db	CTP
2N2066	3	PNPA	Ge	45W	1.5	80	65		PG at 2.0W	32-39db	CTP
2N2067	3	PNPA	Ge	28W	2.5	40	40	.30	PG at 2.0W	28-39db	CTP
2N2067B	3	PNPA	Ge	28W	2.5	40	40	.30	PG at 2.0W	34-37db	CTP
2N2067G	3	PNPA	Ge	28W	2.5	40	40	.30	PG at 2.0W	32-35db	CTP
2N2067-O	3	PNPA	Ge	28W	2.5	40	40	.30	PG at 2.0W	28-33db	CTP
2N2067W	3	PNPA	Ge	28W	2.5	40	40	.30	PG at 2.0W	36-39db	CTP
2N2068	3	PNPA	Ge	28W	2.5	80	70	.30	PG at 2.0W	28-37db	CTP
2N2068G	3	PNPA	Ge	28W	2.5	80	70	.30	PG at 2.0W	32-37db	CTP
2N2068-O	3	PNPA	Ge	28W	2.5	80	70	.30	PG at 2.0W	28-33db	CTP
2N2075	3	PNPA	Ge	170W	.50	80	80	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2075A	3	PNPA	Ge	170W	.50	80	80	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2076	3	PNPA	Ge	170W	.50	70	70	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2076A	3	PNPA	Ge	170W	.50	70	70	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2077	3	PNPA	Ge	170W	.50	50	50	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2077A	3	PNPA	Ge	170W	.50	50	50	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2078	3	PNPA	Ge	170W	.50	40	40	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2078A	3	PNPA	Ge	170W	.50	40	40	5Kc ΔØ	h_{FE}:I_C-1.2A	63	MOT
2N2079	3	PNPA	Ge	170W	.50	80	80	5Kc ΔØ	h_{FE}:I_C-1.2A	100	MOT
2N2079A	3	PNPA	Ge	170W	.50	80	80	5Kc ΔØ	h_{FE}:I_C-1.2A	100	MOT
2N2080	3	PNPA	Ge	170W	.50	70	70	5Kc ΔØ	h_{FE}:I_C-1.2A	100	MOT
2N2080A	3	PNPA	Ge	170W	.50	70	70	5Kc ΔØ	h_{FE}:I_C-1.2A	100	MOT
2N2081	3	PNPA	Ge	170W	.50	50	50	5Kc ΔØ	h_{FE}:I_C-1.2A	100	MOT
2N2081A	3	PNPA	Ge	170W	.50	50	50	5Kc ΔØ	h_{FE}:I_C-1.2A	100	MOT
2N2082	3	PNPA	Ge	170W	.50	40	40	5Kc ΔØ	h_{FE}:I_C-1.2A	100	MOT
2N2085	2,5	NPNA	Ge	150	.50	33	23	8.0	h_{FE}:I_C- 10ma	100	GIC
2SA15	4	PNPA	Ge	80	750	16		12			HITJ
2SA18	5	PNPA	Ge	80	750	21		19			HITJ
2SA19	1	PNP	Ge	15		12		55	h_{fe}:I_c-1.0ma	20	NECJ
2SA20	1	PNP	Ge	15		12		55	h_{fe}:I_c-1.0ma	30	NECJ
2SA21	1	PNP	Ge	15		12		55	h_{fe}:I_c-1.0ma	50	NECJ
2SA26	2	PNPA	Ge	125		20		6.0	h_{fe}:I_e-1.0ma	60	NECJ
2SA42	4	PNPA	Ge	80	180	45		6.0			HITJ
2SA85	4	PNPD	Ge	80	750	25		50			HITJ
2SA86	4	PNPD	Ge	225	200	45		50			HITJ
2SA217	5	PNPA	Ge	120	500	25		18			HITJ
2SA232	3	PNPA	Ge	2000	22.5	30		4.0			HITJ
2SA235	4	PNPD	Ge	80	750	20		125			HITJ
2SA246	4	PNPD	Ge	130	460	30		270			HITJ
2SA247	5	PNPD	Ge	130	460	10		200			HITJ
2SA260	4	PNPMe	Ge	40		20		200†	PG at 100Mc	16db	SANJ
2SA261	9	PNPMe	Ge	40		20		400†	PG at 100Mc	11db	SANJ
2SA262	4	PNPMe	Ge	40		20		400†	PG at 100Mc	19db	SANJ
2SA263	8,9	PNPMe	Ge	40		20		400†	PG at 100Mc	16db	SANJ
2SA264	4	PNPMe	Ge	40		20		600†	PG at 100Mc	21db	SANJ
2SA265	8,9	PNPMe	Ge	40		20		600†	PG at 100Mc	17db	SANJ
2SA285	1	PNPD	Ge	50		18		40	h_{fe}:I_e-1.0ma	70	NECJ
2SA286	1	PNPD	Ge	50		18		50	h_{fe}:I_e-1.0ma	70	NECJ
2SA287	1	PNPD	Ge	50		18		60	h_{fe}:I_e-1.0ma	70	NECJ
2SA290	4	PNPD	Ge	80	750	20		700			HITJ
2SB66	2	PNPA	Ge	150	400	30		.90			HITJ
2SB67	2	PNPA	Ge	350	130	55		1.0			HITJ
2SB68	5	PNPA	Ge	50	120	105		.50			HITJ
2SB73	2	PNPA	Ge	50	120	10		.70			HITJ
2SB80	3	PNPA	Ge	4000	15	25		.60			HITJ
2SB82	3	PNPA	Ge	2000	22.5	100		.40			HITJ
2SB84	3	PNPA	Ge	12W	5.0	60		.40			HITJ
2SB89	2	PNPA	Ge	250	240	25		1.0			HITJ
2SB98	2	PNPA	Ge	125		30		1.5	h_{fe}:I_e-1.0ma	40	NECJ
2SB99	2	PNPA	Ge	125		30		1.5	h_{fe}:I_e-1.0ma	120	NECJ
2SB155	2	PNPA	Ge	450	130	16		.90			HITJ
2SB183	2	PNPA	Ge	50	1200	12		.70			HITJ
2SB203	3	PNPA	Ge		.80	40	30		h_{FE}:I_C- 15A	40	SHEJ
2SB204	3	PNPA	Ge		.80	40	30	3.0Δ	h_{FE}:I_C- 15A	100	SHEJ
2SB205	3	PNPA	Ge		.80	80	60	3.0Δ	h_{FE}:I_C- 15A	40	SHEJ
2SB206	3	PNPA	Ge		.80	80	60	3.0Δ	h_{FE}:I_C- 15A	100	SHEJ
2SB207	3	PNPA	Ge		.80	100	75	3.0Δ	h_{FE}:I_C- 15A	40	SHEJ
2SB209	3	PNPA	Ge		.80	40	30	3.0Δ	h_{FE}:I_C- 15A	100	SHEJ
2SB210	3	PNPA	Ge		.80	40	30	3.0Δ	h_{FE}:I_C- 15A	100	SHEJ
2SB211	3	PNPA	Ge		.80	80	60	3.0Δ	h_{FE}:I_C- 15A	40	SHEJ
2SB212	3	PNPA	Ge		.80	80	60	3.0Δ	h_{FE}:I_C- 15A	100	SHEJ
2SB213	3	PNPA	Ge		.80	100	75	3.0Δ	h_{FE}:I_C- 15A	40	SHEJ
2SB214	3	PNPA	Ge		.80	100	75	3.0Δ	h_{FE}:I_C- 15A	40	SHEJ
2SC22	3	NPNMe	Si		11.5	75	50	110Kc Δ	h_{FE}:I_C-.15A	50	NECJ
2SC23	3	NPNMe	Si		11.5	75	50	110Kc Δ	h_{FE}:I_C-.15A	50	NECJ
2SC24	3	NPNMe	Si		11.5	100	70	110Kc Δ	h_{FE}:I_C-.15A	50	NECJ
2SC91	5	NPNA	Ge	120	500	25		10			HITJ
2SC121	2	NPNG	Si	250		45		25	h_{fe}:I_e-1.0ma	40	NECJ

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C. P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics $f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	MFR. See Code
2SC122	2	NPNG	Si	250		45		30	h_{fe}:I_e-1.0ma	90	NECJ
2SC123	2	NPNG	Si	250		45		35	h_{fe}:I_e-1.0ma	140	NECJ
2SC124	2	NPNG	Si	250		45		35	h_{FE}-I_C-.05ma	40	NECJ
2SC152	3	NPND	Si	750	75	60		160			HITJ
2SC160	4	NPNG	Si	125	1200	20		100			HITJ
2SD75	2	NPNA	Ge	100	600	25		2.0			HITJ
2SD77	2	NPNA	Ge	100	600	25		2.0			HITJ
2SD121	5	NPND	Si	1000	150	100		1.5			HITJ
2SD123	5	NPND	Si	7000	21.4	100		1.2			HITJ
2SD125	5	NPND	Si	21W	7.1	100		1.0			HITJ
AC116	2	PNPA	Ge	150	200	6.0			h_{fe}:I_e-4.0ma	90	TFKG
AC117	2	PNPA	Ge	400	75	6.0			h_{FE}:I_E- 50ma	85	TFKG
AC122	2			60		6.0			h_{fe}:I_e-2.0ma	90	TFKG
AC123	2	PNPA	Ge	150	200	6.0			h_{fe}:I_e-4.0ma	90	TFKG
AC124	2	PNPA	Ge	400	75	6.0			h_{FE}:I_E- 50ma	85	TFKG
AF102	1	PNPAD	Ge	50	600	25		180#	h_{FE}:I_E-1.0ma	20Ø	PHIN
AF118	2	PNPAD	Ge	250	250	50		175#	h_{FE}:I_E- 10ma	200	PHIN
AFZ12	1	PNPAD	Ge	50	600	25		200#	h_{FE}:I_E-1.0ma	50	PHIN
ASY12	2,5	PNPA	Ge	330	90	32			h_{FE}:I_C-600ma	20	INTG
ASY13	2,5	PNPA	Ge	330	90	60			h_{FE}:I_C-600ma	20	INTG
ASY14	2,5	PNPA	Ge	330	300	80			h_{FE}:I_C-125ma	25	INTG
ASZ20	2	PNPAD	Ge	80	600	40		100#	h_{FE}:I_E-1.0ma	45Ø	PHIN
ASZ21	2	PNPAD	Ge	94	500	20		300#	h_{FE}:I_E- 15ma	30Ø	PHIN
AUY10	3	PNPAD	Ge		3.0	75		60Kc#			PHIN
B1013	3	PNPAD	Ge		15	60	25	2.5Kc	h_{FE}:I_C-.50A	53	BEN
B1013A	3	PNPAD	Ge		15	100	50	2.5Kc	h_{FE}:I_C-.50A	53	BEN
B1274	3	PNPAD	Ge		1.2		40		h_{FE}:I_C-5.0A	90	BEN
B1274A	3	PNPAD	Ge		1.2		80		h_{FE}:I_C-5.0A	90	BEN
B1274B	3	PNPAD	Ge		1.2		120		h_{FE}:I_C-5.0A	90	BEN
BC1073	3	PNPAD	Ge		1.2	40	40	1.5	h_{FE}:I_C-5.0A	40	BEN
BC1073A	3	PNPAD	Ge		1.2	80	80	1.5	h_{FE}:I_C-5.0A	40	BEN
BC1073B	3	PNPAD	Ge		1.2	120	120	1.5	h_{FE}:I_C-5.0A	40	BEN
BCY10	2	PNPA	Si	300	400	32		2.0	h_{fe}:I_e- 10ma	50	PHIN
BCY11	2	PNPA	Si	300	400	60		1.5	h_{fe}:I_e- 30ma	20	PHIN
BCY12	2	PNPA	Si	300	400	32		2.0	h_{fe}:I_e-150ma	25	PHIN
C620	2	FET	Si	250	540	10					CRY
C621	2	FET	Si	250	540	10					CRY
C622	2	FET	Si	250	540	10					CRY
C623	2	FET	Si	250	540	10					CRY
C624	2	FET	Si	250	540	10					CRY
C625	2	FET	Si	250	540	10					CRY
CK22C	2	PNPA	Ge	80	750	35		1.2	h_{FE}:I_C-1.0ma	90	RAY
CK64C	2	PNPA	Ge	80	750	45		.80	h_{FE}:I_C-1.0ma	22	RAY
CK65C	2	PNPA	Ge	80	750	45		1.0	h_{FE}:I_C-1.0ma	45	RAY
CK66C	2	PNPA	Ge	80	750	35		1.2	h_{FE}:I_C-1.0ma	90	RAY
CK67C	2	PNPA	Ge	80	750	35		1.5	h_{FE}:I_C-1.0ma	180	RAY
CST1789	3	PNPA	Ge	28W	2.5	120	95	.30	h_{FE}:I_C-.50A	53	CTP
F101	3,5	NPND	Si		2.1	30		1.0	h_{FE}:I_C-1.0ma	30	FTC
F102	3,5	NPND	Si		2.1	60		1.0	h_{FE}:I_C-1.0ma	30	FTC
F103	3,5	NPND	Si		2.1	100		1.0	h_{FE}:I_C-1.0A	30	FTC
F104	3,5	NPND	Si		2.33	30		1.0	h_{FE}:I_C-1.0A	30	FTC
F105	3,5	NPND	Si		2.33	60		1.0	h_{FE}:I_C-1.0A	30	FTC
F106	3,5	NPND	Si		2.33	100		1.0	h_{FE}:I_C-1.0A	30	FTC
F107	3,5	NPND	Si		2.33	30		1.5	h_{FE}:I_C-1.0A	30	FTC
F108	3,5	NPND	Si		2.1	60		1.5	h_{FE}:I_C-1.0A	30	FTC
F109	3,5	NPND	Si		2.1	100		1.5	h_{FE}:I_C-1.0A	30	FTC
F110	3,5	NPND	Si		2.1	60		1.5	h_{FE}:I_C-1.0A	30	FTC
F111	3,5	NPND	Si		2.1	60		1.5	h_{FE}:I_C-1.0A	30	FTC
F112	3,5	NPND	Si		2.1	60		1.0	h_{FE}:I_C-2.0A	30	FTC
F113	3,5	NPND	Si		2.1	60		1.0	h_{FE}:I_C-2.0A	30	FTC
F114	3,5	NPND	Si		2.1	60		1.5	h_{FE}:I_C-2.0A	30	FTC
F115	3,5	NPND	Si		2.33	60		1.0	h_{FE}:I_C-2.0A	30	FTC
F116	3,5	NPND	Si		2.33	60		1.0	h_{FE}:I_C-2.0A	30	FTC
GET870	2	PNPA	Ge	75	650	15		7.5	h_{fe}:I_e-1.0ma	75	GECB
GET880	2	PNPA	Ge	100	600	15		7.5	h_{fe}:I_e-1.0ma	75	GECB
GET887	2	PNPA	Ge	100	600	15		3.5	h_{fe}:I_e-1.0ma	75	GECB
GET888	2	PNPA	Ge	100	600	15		3.5	h_{fe}:I_e-1.0ma	150	GECB
GET889	2	PNPA	Ge	100	600	15		7.5	h_{fe}:I_e-1.0ma	75	GECB
GET890	2	PNPA	Ge	100	600	15		7.5	h_{fe}:I_e-1.0ma	150	GECB
GET891	2	PNPA	Ge	100	600	20		3.5	h_{FE}:I_E- 25ma	45	GECB
GET892	2	PNPA	Ge	100	600	20		7.5	h_{FE}:I_E- 25ma	65	GECB
GFT41	1,2,5	PNPD	Ge	50	1000	15	10	120	PG at 200Mc	18db	TKAD
GFT43A	2,4,5	PNPD	Ge	50	1000	15	10	20Ø	PG: I_e-1.0ma	26db	TKAD
GFT43B	2,4,5	PNPD	Ge	50	1000	15	10	30Ø	PG: I_e-1.0ma	55db	TKAD
HA7206	2	PNPMe	Si	250	500	70		45	h_{fe}:I_e-2.0ma	10	HUG
HA7207	2	PNPMe	Si	250	500	70		55	h_{fe}:I_e-2.0ma	10	HUG
HA7520	3	PNP	Si	1000	140	35		1.2	h_{fe}:I_e-1.0ma	12	HUG
HA7521	3	PNP	Si	1000	140	60		1.2	h_{fe}:I_e-1.0ma	12	HUG
HA7530	2	PNP	Si	400	340	35		1.2	h_{fe}:I_e-1.0ma	12	HUG
HA7531	2	PNP	Si	400	340	60		1.2	h_{fe}:I_e-1.0ma	12	HUG
HA7597	3	PNPA	Si	1000	150	50		.20	h_{fe}:I_e-3.0ma	14	HUG
HA7598	3	PNPA	Si	1000	150	50		.30	h_{fe}:I_e-3.0ma	25	HUG
HA7599	3	PNPA	Si	1000	150	50		.40	h_{fe}:I_e-3.0ma	50	HUG
HA7630	2	PNPA	Si	400		40		1.0	h_{fe}:I_e-5.0ma	22	HUG
HA7631	2	PNPA	Si	400		80		1.0	h_{fe}:I_e-5.0ma	22	HUG
HA7632	2	PNPA	Si	400		40		1.0	h_{fe}:I_e-5.0ma	60	HUG
HA7633	2	PNPA	Si	400		80		1.0	h_{fe}:I_e-5.0ma	60	HUG
HA7730	3	PNPA	Si	1000	150	40		1.0	h_{fe}:I_e-5.0ma	22	HUG
HA7731	3	PNPA	Si	1000		80		1.0	h_{fe}:I_e-5.0ma	22	HUG
HA7732	3	PNPA	Si	1000		40		1.0	h_{fe}:I_e-5.0ma	60	HUG
HA7733	3	PNPA	Si	1000		80		1.0	h_{fe}:I_e-5.0ma	60	HUG
HA9054	2,5	PNPMe	Si	250	550	15		25Ø	h_{fe}:I_e-2.0ma	25	HUG
HA9055	2,5	PNPMe	Si	250	550	15		40Ø	h_{fe}:I_e-2.0ma	55	HUG
HA9056	2,5	PNPMe	Si	250	550	30		25Ø	h_{fe}:I_e-2.0ma	25	HUG
HA9057	2,5	PNPMe	Si	250	550	30		40Ø	h_{fe}:I_e-2.0ma	55	HUG
HA9058	2,5	PNPMe	Si	250	550	50		25Ø	h_{fe}:I_e-2.0ma	25	HUG
HA9059	2,5	PNPMe	Si	250	550	50		40Ø	h_{fe}:I_e-2.0ma	55	HUG
HA9531	2	PNPMe	Si	300	500	50		100	h_{FE}:I_C-150ma	25	HUG
HA9531A	2	PNPMe	Si	300	500	60		100	h_{FE}:I_C-150ma	25	HUG
HA9532	2	PNPMe	Si	300	500	50		100	h_{FE}:I_C-150ma	40	HUG
HA9532A	2	PNPMe	Si	300	500	60		100	h_{FE}:I_C-150ma	40	HUG
NKT121	2	PNP	Ge	75	660	20		15	h_{FE}:I_E-500ma	80	NTLB
NKT122	2	PNP	Ge	75	660	20		7.0	h_{FE}:I_E-500ma	80	NTLB
NKT123	2	PNP	Ge	75	660	20		3.0	h_{FE}:I_E-500ma	80	NTLB
NKT124	2	PNP	Ge	75	660	20		15	h_{FE}:I_E- 25ma	120	NTLB

NOTATIONS

Under Use

1- Low power a-f equal to or less than 50 mw
2- Medium power a-f 50 mw and equal to or less than 500 mw
3- Power>500 mw
4- r-f/i-f
5- Switching and Computer
6- Low Noise
7- Photo
8- Mixer
9- Local Oscillator
☑- Revised Spec.
10- Chopper
11- Matched Pair
12- Video Amplifier
13- TV Sync. Separator

FET—Field Effect Transistor

Under Type

A- Alloyed
D- Diffused or Drift
E- Epitaxial Mesa
F- Fused
G- Grown
H- Hook Collector
M- Microalloy
PL- Planar
Me- Mesa
O- Other
S- Surface Barrier
UNI - Unijunction Transistor
Y - Symmetrical
§ Tetrode

Under Gain Value

Ø - Pulsed

Under fab

* — Maximum Frequency
# — Figure of Merit
Δ — $f_{\alpha e}$
Ø — Minimum
↑ — f_T (Gain Bandwidth Product)
☑ — f_{os} max. (Max. freq. of oscillation)

Under Derating

Ø - Infinite heat sink

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C.				Typical Characteristics			MFR. See Code
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	
NKT125	2	PNP	Ge	75	660	20		17	h_{FE}:I_E- 25ma	120	NTLB
NKT126	2	PNP	Ge	75	660	20		3.0	h_{FE}:I_E- 25ma	120	NTLB
NKT127	2	PNP	Ge	75	660	20		15	h_{FE}:I_E-1.0ma	80	NTLB
NKT128	2	PNP	Ge	75	660	20		17	h_{FE}:I_E-1.0ma	80	NTLB
NKT129	2	PNP	Ge	75	660	20		3.0	h_{FE}:I_E-1.0ma	80	NTLB
NKT141	2	PNP	Ge	125	400	15		15	h_{fe}:I_e-1.0ma	150	NTLB
NKT142	2	PNP	Ge	125	400	15		8.0	h_{fe}:I_e-1.0ma	100	NTLB
NKT143	2	PNP	Ge	125	400	15		3.0	h_{fe}:I_e-1.0ma	80	NTLB
NKT144	2	PNP	Ge	125	400	15		3.0	h_{fe}:I_e-1.0ma	80	NTLB
NKT221	2	PNP	Ge	300	200	30		1.5	h_{FE}:I_E-500ma	70	NTLB
NKT222	2	PNP	Ge	180	280	30		1.5	h_{FE}:I_E- 25ma	150	NTLB
NKT223	2	PNP	Ge	180	280	30		1.5	h_{fe}:I_e-1.0ma	45	NTLB
NKT224	2	PNP	Ge	180	280	30		1.5	h_{fe}:I_e-1.0ma	35	NTLB
NKT225	2	PNP	Ge	180	280	30		1.5	h_{fe}:I_e-1.0ma	100	NTLB
NKT226	2	PNP	Ge	180	280	30		1.5			NTLB
NKT227	2	PNP	Ge	180	280	60		1.5	h_{FE}:I_E- 25ma	150	NTLB
NKT228	2	PNP	Ge	300	200	30		1.5	h_{FE}:I_E-500ma	70	NTLB
NKT401	3	PNP	Ge		1.5	80		.60	h_{FE}:I_C-6.0A	33	NTLB
NKT402	3	PNP	Ge		1.5	60		.60	h_{FE}:I_C-6.0A	60	NTLB
NKT403	3	PNP	Ge		1.5	80		.60	h_{FE}:I_C-1.0A	100	NTLB
NKT404	3	PNP	Ge		1.5	60		.60	h_{FE}:I_C-1.0A	100	NTLB
NS345	2,5	NPNMe	Si	300			35		h_{fe}:I_c- 10ma	140	NAC
NS381	2,5	NPNE	Si	300	500	25		300	h_{FE}:I_C-3.0ma	40	NAC
NS382	2,5	NPNE	Si	300	500	25		300	h_{FE}:I_C-3.0ma	80	NAC
NS383	2,5	NPNE	Si	300	500	20		300	h_{FE}:I_C-3.0ma	40	NAC
NS384	2,5	NPNE	Si	300	500	20		300	h_{FE}:I_C-3.0ma	80	NAC
OC303	2	PNPA	Ge	67	450		15	.70	h_{fe}:I_e-1.0ma	26	INTG
OC364	1	PNPA	Ge	30	1000		7.0	2.5	h_{fe}:I_e-.50ma	85	INTG
PADT35	2	PNP	Ge	200	250	50		175	h_{fe}:I_e- 10ma	200	AMP
PADT40	2	PNP	Ge	94	250	20		300	h_{fe}:I_e- 30ma	50	AMP
PADT60	2	PNP	Ge	83		35	50				AMP
PD3L	2		Ge	100		50		.02			NECJ
PD6	1		Ge	20		50		.04			NECJ
RT409E	2	NPNMe	Si	400	330	60		150	h_{FE}:I_E-150ma	40	RHE
RT482	3	NPNMe	Si	600	200	20		150	h_{FE}:I_E- 30ma	50	RHE
RT483	3	NPNMe	Si	600	200	40		150	h_{FE}:I_E-150ma	40	RHE
RT484	3	NPNMe	Si	600	200	40		150	h_{FE}:I_E-150ma	70	RHE
RT497M	2	NPNMe	Si	400	350	60		150	h_{fe}:I_e-200ma	20	RHE
RT498M	2	NPNMe	Si	400	350	100		150	h_{fe}:I_e-200ma	20	RHE
RT656M	2	NPNMe	Si	400	350	60		150	h_{fe}:I_e-200ma	60	RHE
RT657M	2	NPNMe	Si	400	350	100		150	h_{fe}:I_e-200ma	60	RHE
RT5151	3	NPNMe	Si	600	200	45		150	h_{FE}:I_E-150ma	60	RHE
RT5152	3	NPNMe	Si	600	200	45		150	h_{FE}:I_E-150ma	60	RHE
RT5203	3	NPNMe	Si	600	200	40		150			RHE
RT5204	3	NPNMe	Si	600	200	30		150		70	RHE
RT5212	3	NPNMe	Si	600	200	60		150		70	RHE
RT5230	3	NPNMe	Si	600	250	30		150	h_{fe}:I_e-.05ma	40	RHE
SFT221	2	PNPA	Ge	225	270	30	24	1.3	h_{FE}:I_C-100ma	30	CSF
SFT222	2	PNPA	Ge	225	270	30	24	1.6	h_{FE}:I_C-100ma	50	CSF
SFT223	2	PNPA	Ge	225	270	30	24	2.6	h_{FE}:I_C-100ma	80	CSF
SFT234	2	PNPA	Ge	450	130	80	50		h_{FE}:I_C-1.0A	40	CSF
SFT235	2	PNPA	Ge	450	130	100	60		h_{FE}:I_C-1.0A	40	CSF
SFT241	2	PNPA	Ge	225	270	45			h_{FE}:I_C-100ma	45	CSF
SFT251	2	PNPA	Ge	225	270	30	24	1.2	h_{fe}:I_c-1.0ma	30	CSF
SFT252	2	PNPA	Ge	225	270	30	24	1.6	h_{fe}:I_c-1.0ma	50	CSF
SFT253	2	PNPA	Ge	225	270	30	24	2.4	h_{fe}:I_c-1.0ma	80	CSF
SFT306	2	PNPA	Ge	150	400	18		3.0	h_{fe}:I_c-1.0ma	28	CSF
SFT307	2	PNPA	Ge	150	400	18		7.0	h_{fe}:I_c-1.0ma	40	CSF
SFT308	2	PNPA	Ge	150	400	18		13	h_{fe}:I_c-1.0ma	70	CSF
ST25A	2	NPN	Si	150		45		25	h_{fe}:I_c-1.0ma	15	NECJ
ST25B	2	NPN	Si	150		45		25	h_{fe}:I_c-1.0ma	32	NECJ
ST25C	2	NPN	Si	150		45		25	h_{fe}:I_c-1.0ma	60	NECJ

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C.				Typical Characteristics			MFR. See Code
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	
ST6511	2	NPN	Si	2.0W	88	40	20		h_{FE}:I_C-150ma	20min	TRA
ST6512	2	NPN	Si	2.0W	88	40	20		h_{FE}:I_C-150ma	40min	TRA
TA2084	3	NPNMe	Si		20Ø	140	140				RCA
THP169	2	FET	Ge	80	3300			110			FTHF
THP170	1	FET	Ge	50	3300						FTHF
THP171	2	FET	Ge	80	3300	80					FTHF
THP172	1	FET	Ge	50	3300	50					FTHF
TI363	4	PNPO	Ge	100		27		180	h_{fe}: 455kc	36db	TI
TI364	4	PNPO	Ge	100		27		180	h_{fe}: 455kc	36db	TI
TI365	4	PNPO	Ge	100		22		180	h_{fe}: 30Mc	11db	TI
TI366	3	PNPA	Ge	25W			45	.50	h_{FE}: 1.0A	75	TI
TI367	3	PNPA	Ge	25W			40	.50	h_{FE}: .50A	60	TI
TI368	3	PNPA	Ge	25W			25	.50	h_{FE}: 1.0A	75	TI
TI369	3	PNPA	Ge	25W			25	.50	h_{FE}: .50A	60	TI
TI370	3	PNPA	Ge	25W			15	.50	h_{FE}: .50A	60	TI
TI385	4	PNPO	Ge	100		27		180	h_{fe}: 10Mc	21	TI
TI386	4	PNPO	Ge	100		27		180	h_{fe}: 10Mc	21	TI
TI387	4	PNPO	Ge	100		27		180	h_{fe}: 10Mc	20	TI
TI388	4	PNPO	Ge	100		27		180	h_{fe}: 10Mc	21	TI
TI389	4	PNPO	Ge	100		27		180	h_{fe}: 10Mc	21	TI
TI390	4	PNPO	Ge	100			15	180	h_{fe}: 10Mc	20	TI
TI391	4	PNPO	Ge	100			15	180	h_{fe}: 10Mc	20	TI
TI392	4	PNPO	Ge	100			15	180	h_{fe}: 10Mc	18	TI
TI393	4	PNPO	Ge	100			15	180	h_{fe}: 10Mc	21	TI
TI394	4	PNPO	Ge	100			25	180	h_{fe}: 10Mc	18	TI
TI480	3	NPNG	Si	600	170	50			h_{fe}:I_c-5.0ma	20	TI
TI481	3	NPNG	Si	600	170	80			h_{fe}:I_c-5.0ma	20	TI
TI482	3	NPNMe	Si	600	200	20		150	h_{FE}:I_C-150ma	40	TI
TI483	3	NPNMe	Si	600	200	40		150	h_{FE}:I_C-150ma	40	TI
TI484	3	NPNMe	Si	600	200	40		150	h_{FE}:I_C-150ma	75	TI
TI485	2	NPNMe	Si	300	410	20		750	h_{FE}:I_C- 10ma	45	TI
TI493	2	NPNG	Si	125	800	40		20	h_{FE}:I_C- 10ma	30	TI
TI494	2	NPNG	Si	125	800	40		20	h_{FE}:I_C- 10ma	80	TI
TI495	2	NPNG	Si	125	800	40		20	h_{FE}:I_C- 10ma	180	TI
TI496	3	NPNG	Si	600	170	40			h_{FE}:I_C-3.0ma	10	TI
TI711A	2	PNPMe	Ge	150	500	18		360†	h_{FE}:I_C- 50ma	50	TI
TS601	2	PNP	Ge	200		12			h_{FE}:I_C- 10ma	45	TUN
TS602	2	PNP	Ge	200		12			h_{FE}:I_C- 10ma	75	TUN
TS603	2	PNP	Ge	200		20			h_{FE}:I_C- 10ma	45	TUN
TS604	2	PNP	Ge	200		20			h_{FE}:I_C- 10ma	75	TUN
TS605	2	PNP	Ge	150		12			h_{FE}:I_E-.25ma	45	TUN
TS606	2	PNP	Ge	150		20			h_{FE}:I_E-.25ma	45	TUN
TX116-1	3	PNPMe	Si	800		60		150	h_{FE}:I_C- 10ma	60	SONY
TX116-2	3	PNPMe	Si	800		60		150	h_{FE}:I_C- 10ma	60	SONY
TX116-3	3	PNPMe	Si	800		60		150	h_{FE}:I_C- 10ma	60	SONY
WX115XD	3	NPNF	Si		.45	200	200	19Δ	h_{FE}:I_C- 10A	13	WESY
WX115UA	3	NPNF	Si		.50	50	50	11Δ	h_{FE}:I_C- 10A	100min	WESY
WX115UB	3	NPNF	Si		.50	100	100	11Δ	h_{FE}:I_C- 10A	100min	WESY
WX115UC	3	NPNF	Si		.50	150	150	11Δ	h_{FE}:I_C- 10A	100min	WESY
WX115XA	3	NPNF	Si		.50	50	50	11Δ	h_{FE}:I_C- 10A	400min	WESY
WX115XB	3	NPNF	Si		.50	100	100	11Δ	h_{FE}:I_C- 10A	400min	WESY
WX115XC	3	NPNF	Si		.50	150	150	11Δ	h_{FE}:I_C- 10A	400min	WESY

NOTATIONS

Under Use

1- Low power a-f equal to or less than 50 mw
2- Medium power a-f 50 mw and equal to or less than 500 mw
3- Power>500 mw
7- Photo
8- Mixer
9- Local Oscillator
☑- Revised Spec.
10- Chopper
11- Matched Pair

Under Type

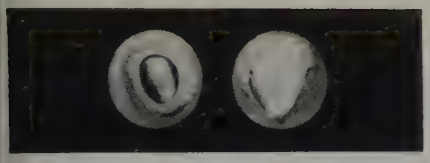
A- Alloyed
D- Diffused or Drift
E- Epitaxial Mesa
F- Fused
G- Grown
H- Hook Collector
Me- Mesa
O- Other
S- Surface Barrier
UNI - Unijunction Transistor
Y- Symmetrical

Under fab

* — Maximum Frequency
# — Figure of Merit
Δ — $f_{\alpha e}$
Ø - Minimum
† — f_T (Gain Bandwidth Product)
☑— $f_{\alpha s}$ max. (Max. freq. of

New Products

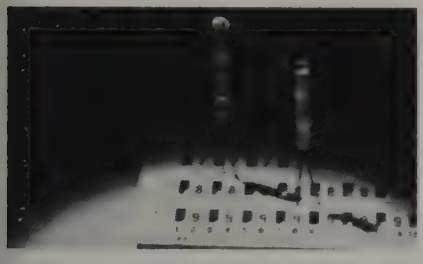
Rosin-Core Solder



A rosin-core solder that provides up to 33 1/3% greater flow is now available from Alpha Metals, Inc. This property insures greater reliability of solder connections, increased wetting, and more joints per pound. Consists of a solder wire center core coated with flux, then covered with an outer sleeve of solder. It is available in all alloys of tin-lead and may be had in tin-lead-silver for soldering silver-fired ceramic parts. It is supplied in diameters from .032" up, and in varying flux percentages. Meets Federal Specifications QQ-S-571C. Photo shows ordinary solder on left, Alpha Cen-Tri-Core solder's greater flow on right.

Circle 140 on Reader Service Card

Silicon Photosensors



Philco Corporation's Lansdale Division has announced a new line of silicon photosensors with high voltage capabilities making possible greater economies in the design of photo diode readout circuitry for data processing equipment. The new photosensors are capable of handling up to 20 volts of reverse breakdown voltage with under 10 ua of leakage current. Absolute Maximum Ratings: Operating Temperature −65°C to +150°C, Storage Temperature +175°C, Reverse Bias Voltage for L-4412 (at 25°C) 20 V d-c, Reverse Bias Voltage for L-4413 (at 25°C) 20 V d-c.

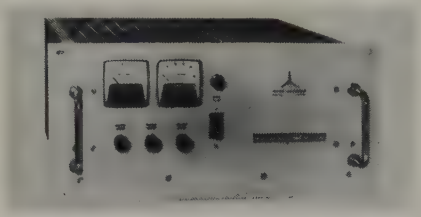
Circle 126 on Reader Service Card

Glass Diode Final Sealer

Research Instrument Co., final sealer is a programmed, batch type unit. It is equipped to seal seven diodes per cycle, under inert gas pressure. Machine features: Individually closing chucks for the sleeve assemblies; whiskers individually weight loaded for ohmic contact; air purged from bell without waste of inert gas; diodes or parts ejectable by air from chucks. Theoretical production is 700 diodes per hour. This is achieved with two units per operator. 1500-2000 Volt Silicon Diodes have been made, without the aid of coatings in this equipment. Built to order in appx. 2 mo.

Circle 106 on Reader Service Card

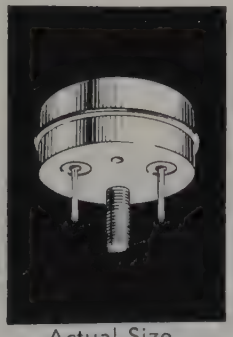
High Current Regulated Power Supplies



Trygon Electronics announces the Century Series high current regulated d-c power supplies. The series covers eight units ranging from 0-15 VDC at 80 amperes to 0-160 VDC at 16 amperes with line and load regulation of better than 0.03% and ripple less than 1 mv RMS. All units have adjustable current limiting automatic short circuit protection and are capable of remote programming over the entire voltage range up to rated output current.

Circle 133 on Reader Service Card

Transistor Enclosure



Actual Size

Shown in the above photograph is the SAC-seal type 110, product of Scully-Anthony Corporation. The enclosure is specifically designed for sealing by the Koldweld* process. *(Registered trade mark of Utica Koldweld Division of Kelsey-Hayes.) No solders, fluxes, heat or sparking results. Special tools required are available.

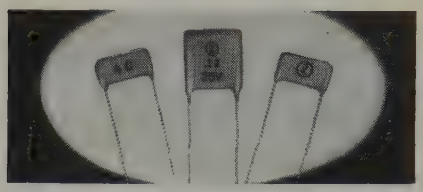
Circle 124 on Reader Service Card

Centrifuge

The DeLaval Separator Company solids accumulating centrifuge recovers germanium dust lost to the coolant used in a slicing operation. Separation is relatively simple because of the large specific gravity differential between germanium and the coolant. Use of a solids-accumulating bowl eases recovery of the separated sludge, which packs hard and dry. The bowl is cleaned once a week and all the germanium sludge is reclaimed. Since all liquid contact parts in the centrifuge are stainless steel, the slightly acidic coolant has no ill effect on the equipment, according to the company.

Circle 137 on Reader Service Card

Ceramic Capacitors



Compact layer-built ceramic capacitors for use in transistor circuits with practically "zero temperature coefficient" have been introduced by Sprague Electric Company as the newest members of its family of Monolythic capacitors. The N030 units are held to so close a temperature coefficient on the nominal negative TC of 30ppm/°C that they may be classed as NPO temperature coefficient units by existing industry and military standards. Standard units are available from ratings of 51$\mu\mu$F to 5100$\mu\mu$F at 200 volts d-c at 85°C, or 50 volts d-c at 125°C.

Circle 121 on Reader Service Card

Eutectic Alloys

Automation Alloys has developed a method of production of Au/6Si eutectic alloy strips and punched preforms, to as low as 0.001" thickness, and with width or preform diameter approaching 0.5" to 0.75". The special method enables them to do so without the formation of the oxide layer on top. Thus, they offer free-flowing Gold/Silicon eutectic alloy preforms, in experimental as well as production quantities. The company also is in full scale production of accurate inlays, overlays, single and sandwich clad materials.

Circle 116 on Reader Service Card

Precision Glass Diode Packages

T. H. Garner Co. announces complete, in-plant facilities for the fabrication of precision glass diode packages. Diamond saws simultaneously cut multiple glass tubes to square, smooth end configurations, holding a tolerance of .001" to .002" on length. Roundness of bodies is held to less than .0015". Concentricity: less than .002" T.I.R. Bead roundness is held to less than .001". Bead concentricity: less than .002" T.I.R.

Circle 129 on Reader Service Card

Crucible Furnace

Lindberg Engineering Company announces their new KEC6-49 crucible furnace with recommended operation at temperatures of 1400°F to 2800°F. The manually operated, bottom loading unit with a heated chamber of 4" by 4" by 9" high has a vertical lift mechanism for ease of loading and discharging work. When lowered from the chamber, the work load rests on a roller conveyor for easy removal or pouring.

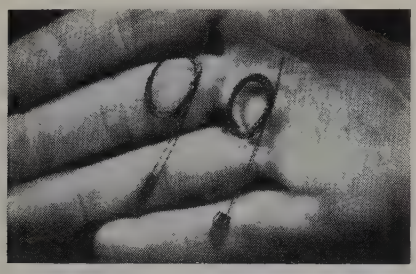
Circle 117 on Reader Service Card

Vacuum System Control

A device which functions like a radio alarm clock now can control or protect the operation of industrial vacuum systems. Called Protectovac Type 0745, the 10-pound unit automatically maintains any preselected level of pressure from 40 to 1000 microns for vacuum furnaces, coaters and pumping systems. Introduced by NRC Equipment Corporation, the device reads a signal from an NRC type 521 thermocouple gauge and opens and closes 5 amp. contacts at the selected pressure point.

Circle 118 on Reader Service Card

High-Performance Hall Devices



Two new Hall-Effect magnetic sensing devices, the Transverse Field and Axial Field "Hall-Paks," have been produced by F. W. Bell, Inc. The transverse field "Hall-Pak," Model BH200, measures only .500" in length, .130" in width and .019" in thickness and is furnished with 7½" leads of #34 ga. copper. The active area is .080" by .180". Model BH203, the axial field "Hall-Pak," is .195" in diameter and 3/16" in total length and carries #34 ga. copper leads 14" long. The active area of this unit is .058" by .148". Both operate in the temperature range of − 40°C to +100°C and are designed for continuous operation at 85°C.

Circle 112 on Reader Service Card

Industrial Transistor

A new fast-switching silicon industrial transistor, the 2N957, is available from Fairchild Semiconductor. Designed for use in VHF and IF amplifiers, it has a voltage rating of 40 volts and a power rating of 800 milliwatts. Guaranteed minimum d-c beta is 45; minimum a-c beta at 1 mc is 40 and at 100 mc is 2. The device is packaged in a JEDEC TO-18 configuration.

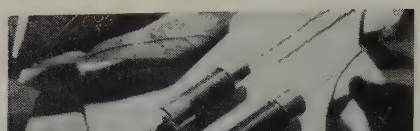
Circle 105 on Reader Service Card

Temperature Testing Center

A convenient, movable test stand designed to centralize temperature tests in one area has been announced by Delta Design, Inc. The unit has a 24" x 30" rubberized working surface which will accommodate the company's series of portable temperature chambers. It also has a similar size storage shelf beneath the unit. Provisions are made for the storage of two fifty pound bottles of Liquid CO_2 used in conjunction with the temperature chambers.

Circle 120 on Reader Service Card

Thin Cell Selenium Rectifiers



General Electric Company announces a new line of miniature "Vac-U-Sel" thin cell selenium rectifiers in a new paper-base, phenolic cartridge. The cells are of .010-inch thin aluminum stock. They are fitted into the new phenolic housing like a stack of pennies in a 50-cent paper bank tube. Stacks are available with up to 500 cells. They operate at 130°C ambient temperature. A single stack used in a half wave circuit will accommodate 15,000 volts and will block a peak reverse voltage of 31,500 volts.

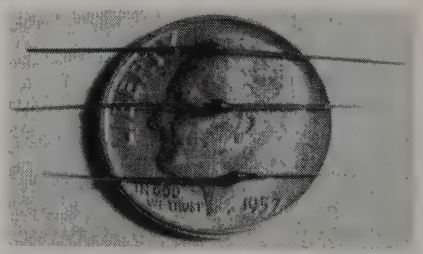
Circle 113 on Reader Service Card

Germanium Alloy Switching Transistors

Latest additions to a series of germanium alloy switching transistors manufactured by Sylvania and approved for military applications by the United States Navy, are two p-n-p and two n-p-n units, which round out a series of four complementary pairs and which meet the requirements of MIL-S-19500/126A. All eight transistors use a TO-5 package outline and have a maximum total power dissipation rating of 150 mw at 25°C in free air. D-C current gain (h^{FE}) runs from a minimum of 20 to a minimum of 80 at I^C = 10 ma, V^{CE} = 1.0 V; and from a minimum of 10 to a minimum of 20 at I^C = 200 ma, V^{CE} = 0.35 V on the respective types.

Circle 100 on Reader Service Card

Silicon Micro-Diodes



General Instrument Semiconductor Division announces a series of silicon micro-diodes, featuring a micro-miniature package, (MD04, MD06, MD08, MD10) for computer and general purpose applications. The peak inverse voltages range from 40 to 100 volts, power dissipation at room temperature is 250 MW, average rectified current rating is 75 MA. This series is characterized by very low reverse leakage current at 150°C. The excellent properties of these micro-diodes are derived through the use of surface passivation techniques on a planar diffused structure.

Circle 101 on Reader Service Card

Silicon Power Transistors

Secoa Electronics Corp., introduces six new high power silicon mesa transistors for switching and amplifier applications. JEDEC types 2N1069, 2N1070, 2N1487, 2N1488, 2N1489 and 2N1490 have low saturation resistance and feature high temperature ceramic to metal insulating seals. These units are rated for 75 watts dissipation at 25°C case temperature. They differ in voltage ratings and beta.

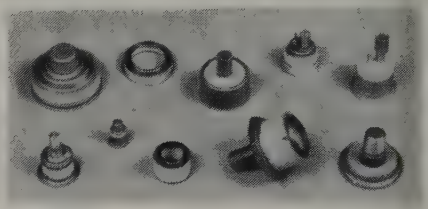
Circle 111 on Reader Service Card

High-Temperature Electric Furnace

A new dual high-temperature, dual-zone unit has been announced by The Pereny Equipment Co., Inc., Model SNXKSG has two immediately adjacent hot zones; one operating at 2900° F while the other operates simultaneously at 2300° F. The high temperature zone is heated with molydiscilicide elements and the other with silicon carbide elements. In order to assure necessary temperature gradients and levels, each chamber is controlled by means of its own individual tap-transformer and direct-reading input ammeter.

Circle 139 on Reader Service Card

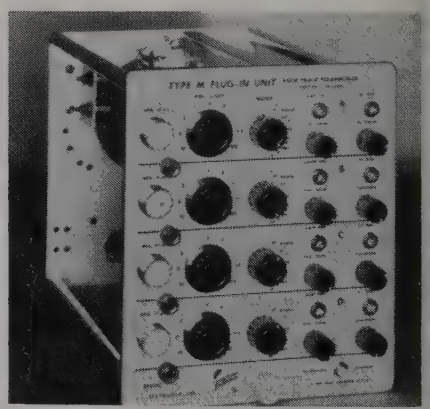
Ceramic-To-Metal Housings



High temperature ceramic-to-metal housings suitable for use in packaging power and controlled rectifiers, and capable of withstanding temperatures to 1700°F, are now available to the semiconductor industry from Advanced Vacuum Products. Sheer strength in the order of 15,000 p.s.i., excellent thermal shock resistance at temperatures of 1000°F, coupled with high thermal conductivity are characteristics of the truly vacuum seal, leak tested 1 x 10^{-9}cc/sec. ADVAC, a subsidiary of Glass-Tite Industries, Inc., is organized and staffed to provide the semiconductor design engineer with assistance and recommendations in the development of rectifier housings.

Circle 110 on Reader Service Card

4-Trace Preamplifier



Seventeenth in the "letter-series" of plug-in units, the new Type M Unit adds multiple-trace displays to the wide range of applications possible with Tektronix oscilloscopes. You can observe up to four signals, either separately, or in any combination. Independent controls for each amplifier channel permit you to position, attenuate, invert input signals as desired. Other convenient features: triggered or free-running electronic switching, a-c or d-c coupling, and, after initial hookup, little or no cable switching.

Circle 102 on Reader Service Card

(Continued on next page)

Silicon Controlled Rectifiers

Texas Instruments Incorporated has introduced the TI-150 Series of 25-amp diffused silicon controlled rectifiers. These new devices eliminate the need for using low-current SCR's in parallel to handle high-current applications. They are rated for an average rectified forward current of 25 amps at 100° C, carrying a maximum d-c current of 35 amps at 95° C. The rated breakover voltages, both forward and reverse, for the Series are 50, 100, 200, 300 and 400 volts respectively.

Circle 104 on Reader Service Card

Miniature Insulators

Ceramics International Corporation is producing miniature insulators for use in transistor research. Dense alumina wafers .014" thick are being produced in .030" square, .050" square and .070" square sizes. The wafers are metalized and gold plated on both sides with no overlap on the thin edges. CI engineers say that they have achieved excellent solderability of the wafers to transistor bases and of miniature components to the wafers. Wafers have been made as small as .008" thick by .018" square.

Circle 131 on Reader Service Card

Controlled Environment System

A controlled environment system incorporating a new type of conveyorized oven has been developed by Temperature Engineering Corporation for the production of high-quality rectifiers at low cost. The Tempcor system can be adapted to the manufacture of a wide variety of electronic components, according to the company. Heart of the controlled atmosphere system is an infra-ray conveyor oven capable of baking out impurities by focusing heat directly on component parts and heating them to within ½° F of the desired temperature.

Circle 114 on Reader Service Card

Desiccator Cabinets

A new clear plastic desiccator cabinet providing a dust-free, humidity-free climate for storage of critical items is now available from Ray Products, Inc. Shelf models have ½" clear plexiglas bodies with fused and flame polished edges secured by a ⅜" door with a rubber gasket seal. Inside dimensions of the cabinet are 12"x12"x12". Three shelves are adjustable to five positions. Hinges and hardware are chrome plated. Suction cup feet permit stacking of several cabinets. Weight is approximately 14 pounds.

Circle 119 on Reader Service Card

Industrial Batch Ovens

These Blue M Ovens are used for general aging, curing, drying, preheating tempering, coil and armature baking, core baking, synthetic finish baking, and many similar procedures. Indicating/Controlling thermostat provides quick reading and setting of oven temperature; with dual scale calibration, enclosed contacts and stainless steel sensing bulb and capillary. Two temperature Ranges: to 356° F (180°C) to 600° F (316°C.) Standard Sizes: from 16 to 96 cubic feet.

Circle 115 on Reader Service Card

Automatic Assembly Machine

A new automatic assembly machine that can produce 6,000 transistor headers an hour has been developed by Rhebo Corporation, subsidiary of Rheem Manufacturing Company. The machine can be adapted to many different precision operations including welding, punching and threading. It can assemble as many as 40 different kinds of parts at the same time. A number of other machines are under development.

Circle 108 on Reader Service Card

Equipment Conversion Kits

Conversion Kits that will change several of its precision instruments and production machines now widely used in the semiconductor and microcircuit industries from manual to semi-automatic operation, are being offered by Kulicke and Soffa Manufacturing Company, Inc. The Kits are designed to increase the production capability by simplifying operation of K&S Models 400, 401, 401AB and 402 Thermocompression Wire Bonders and of K&S Model 310 Production Probe.

Circle 127 on Reader Service Card

Automatic Gas Purifier & Dryer

United States Dynamics, Industrial Equipment Division, announces its new automatic gas purifier and dryer Model SPG-100, designed to remove both oxygen and moisture from hydrogen, forming gas, etc. The device consists of two sections: a Dyn-Oxo Catalytic Precombiner, and an Automatic Gas Dryer and Purifier. The combined unit is contained in a compact cabinet 28" high x 24" wide x 7" deep. Flow rating is 0 to 100 SCFH. Operating pressure range is 0 to 150 PSIG. Higher ranges are available also.

Circle 132 on Reader Service Card

Packaged Mobile Clean Room

CAEMCO is making available an independent, complete, packaged 500 square foot Clean Room complete with air conditioning, filtration system, air shower, lighting, toilet facilities, dressing room, interlock, electric outlets, vinyl walls and floor. The entire unit is factory manufactured and delivered complete and ready for use. Special facilities or components as well as workbench "Sterilhoods" can be provided. The area can be expanded by attaching additional independent mobile units through the use of specially designed air shower interlocks. Available on a rental basis.

Circle 128 on Reader Service Card

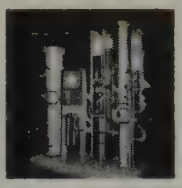
Alumina Semiconductor Polishing

Semiconductor-grade alumina powders for the critical production polishing of silicon and germanium wafers have been developed by the Crystal Products Department of Linde Company, Division of Union Carbide Corporation. These new materials now have tighter stock removal and scratch rating quality control. Type 1.0C powder is used to remove stock from surfaces that are about 6 microinches rms. Type 0.3A can then be used for preliminary polishing and Type 0.05B for the final polishing of the wafers. All are chemically prepared, contain less than 100 parts per million of impurities and have an extremely uniform ultimate particle size.

Circle 109 on Reader Service Card

Demineralizing Equipment NEWS

from Penfield

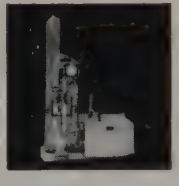


Fully "Packaged" System Supplies 125-150 GPH of 18 Megohm Water

Penfield's new S-150 Demineralizing System includes multiple influent filters to remove turbidity, master dual-column demineralizer, scavenging carbon filter, polishing mono-column demineralizer, sub-micron effluent filter — all completely "packaged" on a single skid, ready to deliver an effluent of 18 megohms and better upon simple connection to service lines. (Other fully "packaged" Penfield systems available with capacities from 60 to 10,000 GPH.)

Pressure-Type Demineralizer "Polishes" to Ultra-High Purity at Point-of-Use

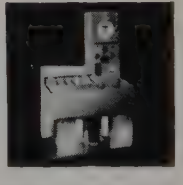
The Penfield PM-8 Demineralizer supplies up to 50 GPH of 18-22 megohm water — is ideal for point-of-use "polishing." Permanent cartridge design prevents raw water by-pass experienced with "canned" resin units. Cartridge unscrews by hand to permit easy resin renewal from bulk supplies, enabling substantial savings in replacement resin costs. Unit also can be charged for use as a cation exchanger, anion exchanger, carbon filter, oxygen or organic remover, and is adaptable for scavenging oil from gases.



In-Plant Regeneration Unit Saves 90% of Costs of Demineralized Water

A Penfield Regeneration Unit makes the renewal of exhausted resins from Point-of-Use Demineralizers an easy in-plant function. Operator merely feeds resin into unit, then turns a single master switch to control resin separation, regeneration, rinsing and proper re-mixing. Average operating cost, including all labor and regenerants, is less than 30c per cartridge.

Fully Integrated Weir Washer "Polishes," Heats, Monitors, Cascading Water



Integral filters and pressure-type demineralizers enable circulation of 18-22 megohm water through multiple partitioned tank of a special weir design that precludes stagnation. Direct reading conductivity meter permits instant monitoring at any of three check points. Novel clip bar makes replacing heat elements simple. (Penfield also constructs weir washer tanks in standard sizes or to customer specifications, using a wide variety of materials such as block tin, cast acrylic plastic, etc.)

15 years of ion exchange pioneering means that Penfield has on file field-proved answers to most industrial water problems — usually can detail the system you need by phone, ship your completely "packaged" units in a matter of days. Try a phone call or letter and see for yourself.

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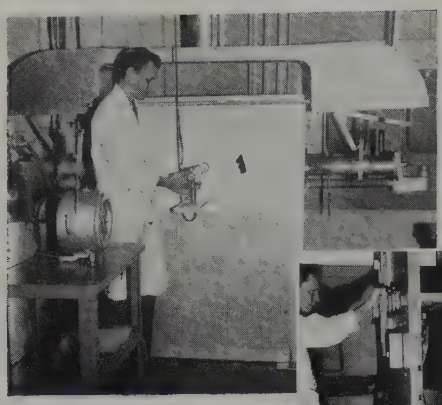
PERECO Carbon Resistor TUBE FURNACE



For temperatures up to **5000° F**

Rocket Material Research —one of many uses

This Pereco CT-412 Tube Furnace, shown installed in the laboratories of Atlantic Research Corporation of Alexandria, Virginia, is being used to research and test rocket materials. But it's equally suited to many other types of industrial or military investigations. Wide range turn-down and with capabilities for holding to plus or minus 20° F at 5000° F insures accuracy of results that can be repeatedly duplicated. Other features of this unit include: great flexibility in choice of extremely rapid or slow cycle heat-up; close control of both temperature and power imput; full range, FAIL-SAFE, safety devices; and easy, low-cost element replacement. Write today for more details—or tell us of your needs, so we can advise as to available Pereco units most suitable for specific applications.

PERENY EQUIPMENT CO., INC.

PERENY EQUIPMENT COLUMBUS OHIO

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NEW SERVICE NOW AVAILABLE

SEMICONDUCTOR PRODUCTS is making a new source of information available to all firms interested in being kept up to date on materials or equipment for producing semiconductor devices. If you wish to receive all new literature on silicon, germanium, chemicals, machinery, or other such materials, circle #99 on the reader-service card. Your name will be placed on a special list which will be forwarded to all such suppliers. As these suppliers have news available in their field, you'll be notified by them immediately. This service is restricted to firms manufacturing semiconductor devices or firms contemplating entering into production within 120 days.

Industry News

CONFERENCE CALENDAR

The Following October 1961 Meetings Are Scheduled:

Oct 1-4 Electrochemical Society Meeting, Statler Hotel, Detroit.

Oct 2-4 7th National Communications Symposium, Utica, N. Y. Sponsored by PGCS, Rome-Utica Section. For Information: R. K. Walker, 34 Bolton Rd., New Hartford, N. Y.

Oct 2-4 IRE Canadian Electronics Conference, Automotive Bldg., Exhibition Park, Toronto, Can. Sponsored by Region 8. For Information: A. R. Low, c/o IRE Canadian Electronics Conference, 1819 Yonge St., Toronto.

Oct 9-11 National Electronics Conference, International Amphitheatre, Chicago. Sponsored by IRE, AIEE, et al. For Information: Dr. Wm. L. Firestone, Motorola, Inc., Chicago.

Oct 16-17 National Symposium on Engineering Writing & Speech, Kellogg Center, Michigan State U., E. Lansing, Mich. Sponsored by PGEWS. For Information: J. D. Chapline, Philco Corp., 3900 Welsh Rd., Willow Grove, Pa.

Oct 16-19 2nd International Congress on Vacuum Technology, Sheraton Park Hotel, Wash., D. C. Sponsored by Internat'l Organization for Vacuum Science & Tech., and American Vacuum Society.

Oct 18-20 Optical Society of America, Annual Meeting. Sponsored by AIP. Biltmore Hotel, Los Angeles.

Oct 19-20 Symposium on Electronics Engng & Education, Greensboro Coliseum, Greensboro, N. C. Sponsored by N.C. Section. For Information: Henry A. Voorhees, 1015 Wendover Circle, Winston-Salem, N. C.

Oct 20th 2nd N. Y. Conference on Electronic Reliability, NYU College of Engng., University Heights, N. Y. For Information: M. A. Benanti, Molecular Electronics, New Rochelle, N. Y.

Oct 25-26 Conference on Reliability Assurance Techniques for Semiconductor Specifications, Dept. of Interior Auditorium, 18th & C Sts., N.W., Wash., D. C. Sponsored by AIA, ASQC, EIA, IRE, JEDEC. For Information: Wm. H. von Alven, ARINC Research Corp., 1700 K Street, N.W., Wash., D. C.

Oct 26-28 Electron Devices Meeting, Sheraton Park Hotel, Wash., D. C. Sponsored by PGED. For Information: Dr. I. M. Ross, Bell Telephone Labs, Murray Hill, N. J.

An estimated 76% of all engineers and scientists employed by the U. S. electronics industry are supported by government funds, according to a survey recently conducted by the Electronic Industries Association with the cooperation of the Department of Defense. The remaining 24% is engaged in commercially supported activities. The report discloses that there are an estimated 155,000 engineers and scientists performing electronics work in all areas. Eighty-three % or 128,000 are employed by industry, while 8% are working for the Federal Government and 5% are doing research work for universities and nonprofit organizations. The remainder comprises independent consultants, engineers and scientists between jobs, and those not identifiable by area of electronic activity.

General Instrument Corporation announced receipt of a contract from the Atomic Energy Commission to develop a model of a first-of-its-kind thermoelectric generator designed to produce electricity directly from the heat of Mixed Fission Products (MFP), the unrefined waste of nuclear reactors.

RESEARCH & DEVELOPMENT

What is believed to be the first thermoelectric generator made of ceramics has been developed by Minneapolis-Honeywell for the U.S. Army. It is capable of operating at unusually high temperatures, up to 2,400 degrees F, and produces four times the voltage of thermoelectric generators made of more commonly used materials such as intermetallics, the company said. Output of the new generator, it added, is 1,000-1,200 microvolts per degree C., compared with 250-300 for intermetallics. A pilot model delivered to the Army's Picatinny Arsenal at Dover, N.J., which supported the development program, is designed to deliver 100 volts under no load.

The generator is made like a cake with 14 layers. The nickel oxide is sprayed on one side of each layer, and platinum on the other. The ceramic and metal then are scored with a diamond-bladed circular saw so that they

THIS IS

ONE USE FOR INDIUM

...there are X more!

"Indalloy" Intermediate Solders, manufactured exclusively by the Indium Corporation and used extensively in printed circuit work, are noted for their wettability (with metallic AND non-metallic surfaces), their corrosion resistance, and their help when special temperatures are important.

Indium solders assist flowability and workability. Adhering readily to many varied surfaces, these solders can be tailor-made for special application. Perhaps you have a need for Indium in solder, spheres, pellet, powder, wire, ribbon or metal forms. Write our research department today... we're glad to help!

INDALLOY SOLDERS

adhere to:

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- 21 thin metal films
- 18 non-metals

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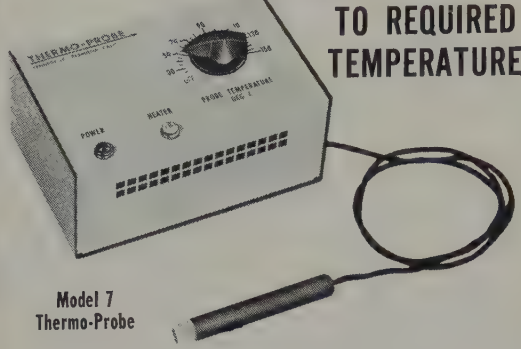
Circle No. 22 on Reader Service Card

New THERMO-PROBE

HEATS TRANSISTORS TO REQUIRED TEMPERATURE



Model 7
Thermo-Probe

Test circuits on the bench —
not in the oven.

Interchangeable tips for transistors, diodes, resistors, crystals, etc.

Probe temperature 25°C to +150°C ±3°C.
Temperature Stability ±0.5°C.
Heater Power 7 watts.

Price $72.50 F.O.B. Altadena (includes tip for TO-5 transistor case). Most special tips: $2.50 each.

KENNEDY COMPANY
2029 N. Lake Ave., Altadena, Calif. MUrray 1-0028

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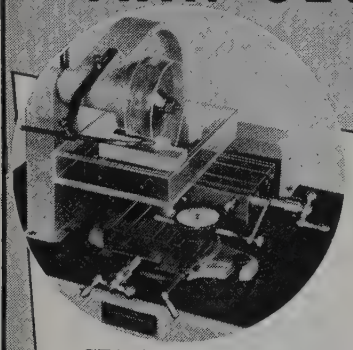
GILLINGS-BRONWILL

THIN SECTIONING MACHINE



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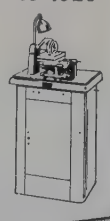
CRYSTAL SECTIONING .005" to .010"

Cut sections as thin as .005" practically plano-parallel from blocks ¾" x 1½" x 3" in less than 5 minutes with this 6500 RPM 4" x .012" diamond wheel. Automatic, two direction, precision table feed. Rate of feed set from ⅜" to ¾" per minute. ¼ H.P., 115 volt, rubber mounted motor. Immediate delivery.



Write for Specifications

BRONWILL SCIENTIFIC
Division of Will Corporation

282 North Goodman St., Rochester 7, N.Y.
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appear to be wrapped around each layer like an unbroken wire. Felt-like ceramic separates the layers. Even the nuts and bolts holding the unit together are made of a special ceramic, since ordinary steel would melt under the unusually high temperatures at which the thermoelectric generator operates.

A second thermoelectric generator being built by Honeywell for the Army will employ the nickel oxide, but will substitute iron oxide for the platinum, producing even higher voltages.

A new type of clock which is at least ten times as accurate as the best conventional chronometer has been developed at the General Electric Research Laboratory, according to Dr. Guy Suits, vice president and director of research. The clock in its present form gains or loses only five seconds a year, and even better performance may be obtained if desired. The device is small and rugged, and operates for about four months on a single size D mercury battery (about the size of a standard flashlight cell). Dr. Suits said the clock is a laboratory device and no plans to produce it commercially have been announced.

The new clock, which was developed by Robert L. Watters, operates on an entirely different principle from that of an ordinary clock. Its timing standard is a quartz crystal, which produces very stable electrical vibrations at a high frequency. The quartz crystal has long been recognized as an almost ideal time standard, but its use in such a compact, practical chronometer became possible only with the recent development of the new solid-state electronic device, the tunnel diode.

Watter's clock uses only three tiny tunnel diodes to convert the 100,000 cycle-per-second crystal vibrations into a 50 cycle-per-second current to drive the clock motor. This is possible because of the unique ability of the tunnel diode to change a high frequency signal into one of much lower frequency, something that is relatively difficult to do using vacuum tubes or transistors.

Scientists at the Westinghouse research laboratories have demonstrated a unique electronic device which might best be described as a "molecular slide rule." The tiny device electronically performs multiplication and division by a process similar to that used in the familiar mechanical slide rule.

The multiplying and dividing function performed by a new functional block is equivalent to that done by an array of four separate diodes, or three diodes and a transistor. The functional block, however, is capable of greater accuracy than the assembly of individual components. The new functional electronic block multiplies by adding together voltages that are logarithms of the quantities to be multiplied.

The molecular slide rule performs electronically by means of semiconductor junctions. An electric current fed into a junction gives a voltage across the junction proportional to the logarithm of the current. An input of two currents into two junctions gives a voltage which is their logarithmic sum. The antilogarithm, measured at the output of the functional block, is the product of multiplying them together. Division is the opposite process. The currents are fed into the multiplier-divider in such a way that their two logarithms subtract instead of add. Used for multiplication or division, the new device has an input range of 10 to one and an output range of 100 to one. Its accuracy in multiplying and dividing is within 5%.

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Semi-conductor precision metal stampings and deep-drawn parts. Made to close tolerance at low cost. Fast service. Write or phone for prices and free copy of Bulletin 82.

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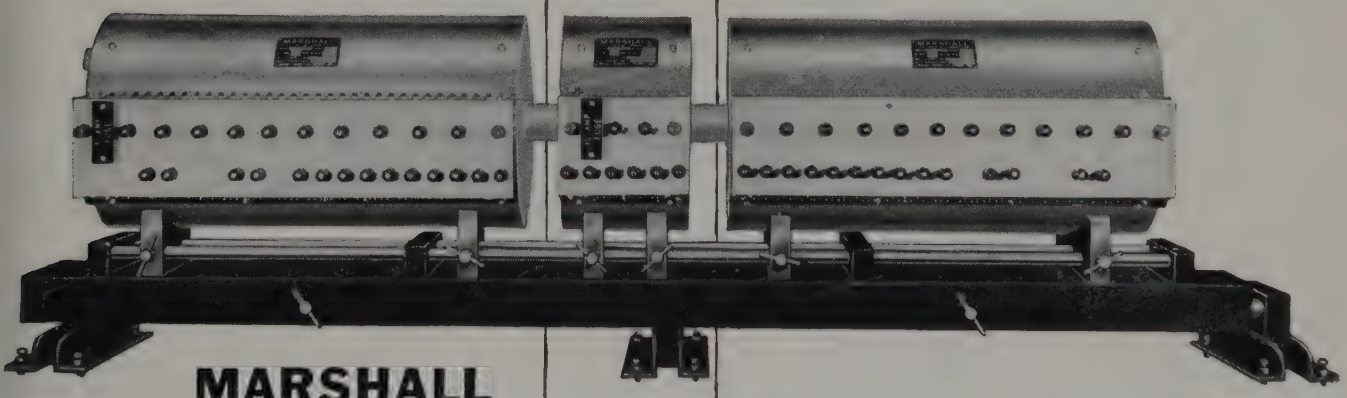
NEW!

Typical combination for preparing gallium arsenide consists of 2 furnaces 2"ID x 10"OD x 20" and 1 furnace 2"ID x 10"OD x 6". Note adjustable spacing between furnaces, Thomson rods and ball bushings for linear motion of entire unit.



MARSHALL
furnace apparatus for
SEMI-CONDUCTOR PRODUCTION

...permits zone refining and directional freezing

Model 60-SC furnace apparatus is designed for semiconductor preparation and growing single crystal materials. It consists of two or more tubular furnaces mounted on a common axis with a quartz reaction tube running through all furnace chambers. This arrangement permits zone refining and directional freezing of most semi-conductor materials. Furnaces are available in temperature ranges to 1400° C., can maintain uniform zones of ±1° C., and have sufficient shunt taps to establish any reasonable temperature profile within the chamber. Furnaces can be spaced to establish sharp temperature gradients between adjoining units, and can be driven in tandem along the support stand at speeds from ⅛″ to 9″ per hour. Marshall can supply the complete package of appropriate furnaces, support stand, drive unit, and temperature controls, for horizontal operation (shown above) or in vertical position for "Bridgman Drop" experiments. Ask for specification sheet 825-A.

Marshall Products Co. *tubular furnaces and control panels*
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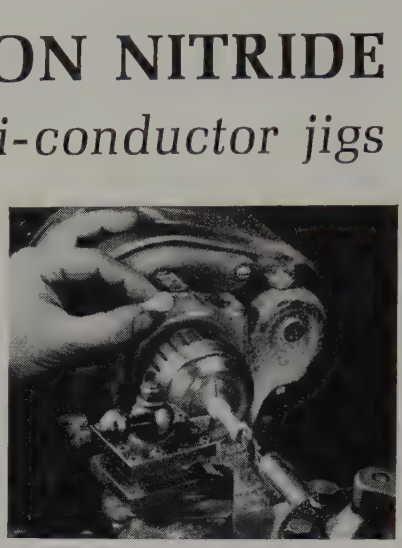
Problem: "On spec" yield of semi-conductor components drop as much as 40% within 50 cycles when using *graphite* jigs

Solution: **BORON NITRIDE**
for semi-conductor jigs



Boron nitride machines easily to close tolerances, resists chipping and retains internal jig details. It holds dimensions, has excellent release characteristics and is non-toxic.

Contact with silicon, germanium, indium, antimony, lead and other metals has little effect up to 1800 F in oxidizing or reducing atmospheres. For more information on greater yields with boron nitride, write Latrobe Plant, Refractories Div., Carborundum Co., Latrobe, Pa.

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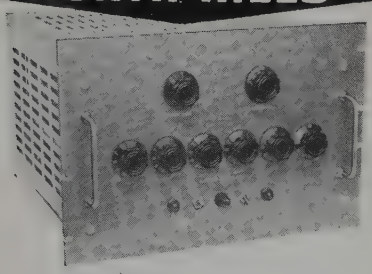

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GYRO TORQUER SUPPLY

- Precision Current Source
- DC and/or AC
- Pulse Output Possible

For testing and measurement of gyro torquers, zener, reference diodes, magnetic components, other current sensitive devices.

- Current Range is 0.1 μa to 150 ma
- Regulation 0.002%
- Resolution 1 part per million

In use by leading companies for gyro torquer supply, component reliability testing, calibration, reference zener testing.

Literature describing this and other constant current sources from 0.1μa to 30 amp. may be obtained from

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ELECTRONICS, INCORPORATED
GLEN COVE, L.I., N.Y. | ORiole 1-5700

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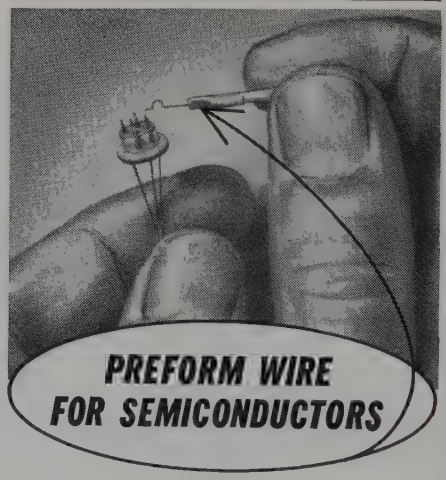

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Successfully used in TO-5 and half-size TO-18 packages.

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Circle No. 29 on Reader Service Card

New Literature

The features and equipment of six models of radio frequency heating units are described in a series of bulletins issued by Lindberg Engineering Company. The units described are designed to convert powerline energy to high-frequency electrical energy suitable for induction heating of metals and other electrical conducting materials.

Circle 150 on Reader Service Card

Tektronix two-page specification sheet details characteristics of two systems for observation and measurement of current waveforms. The P6016 AC Current Probe and Type 131 Amplifier constitute a current-detecting system for use with a wideband oscilloscope. The P6016 AC Current Probe with a Passive Termination provides for observation and measurement of current waveforms at frequencies to 20 mc (with 30-mc oscilloscope) and sensitivity of either 2 or 10 ma/mv (of oscilloscope sensitivity).

Circle 151 on Reader Service Card

Semi-Alloys, Inc., lists hundreds of different alloys, in their data sheet on semiconductor materials, which meet the most stringent requirements. Basically, these include aluminum, gold, silver, indium, tin and lead, which are in turn combined with one or more of most of the non-gaseous elements in the periodic table.

Circle 152 on Reader Service Card

Computer Techniques has just completed its catalog for the 1200 series of digital logic modules. This 16-page, two color catalog contains detailed information for the use of logic modules with typical applications for shift registers, accumulators and counters. Incorporated are detailed illustrations, block diagrams and schematics.

Circle 153 on Reader Service Card

A newly revised catalog detailing all technical specifications and capacities of their Heat-Les dynamic desiccant dryers is now available from Trinity Equipment Corporation. In addition to listings of standard and new model sizes, the catalog contains complete formulae and tables for sizing this type of dryer.

Circle 154 on Reader Service Card

Technical Bulletin AV-100, a 2-page data sheet, describing ceramic-to-metal housings for high-power high-current semiconductor rectifiers, is now available from Advanced Vacuum Products, Inc. The first in a series describing ADVAC's line of metallized ceramic products for semiconductor applications, it includes a photo showing typical rectifier housings, as well as a line drawing showing construction details which will be highly useful to semiconductor design engineers. The Bulletin also lists complete electrical and mechanical properties of the high alumina ceramic used in this application.

Circle 155 on Reader Service Card

A revised Plastic Fact File describing the properties and typical end uses of the diversified line of materials produced by Monsanto Chemical Company's Plastics Division is available. The 16-page booklet includes detailed results of American Society for Testing Materials tests on the company's broad range of Lustrex styrene, Monsanto Polyethylene, Opalon vinyl chloride and Lustran SAB and SAN molding and extrusion compounds.

Circle 156 on Reader Service Card

Bulletin 03-201-A discusses the features, selection, and applications of an improved selenium photovoltaic cell developed in the Solid State Laboratories of Daystrom, Incorporated, Western Instruments Division. The cells are described in text, photographs, and drawings. Technical data supplied ranges from explanations of current output and spectral response to dimensional diagrams.

Circle 163 on Reader Service Card

A new 23 page catalog describes F. J. Cooke Inc., high vacuum systems, instruments and valves. Featured under systems are high temperature, cold jacket furnaces and special purpose vacuum evaporators. The instrument section includes an ionization gauge control with automatic range switching. A series of right angle cast stainless steel valves is described. Detailed descriptions and technical specifications are provided.

Circle 164 on Reader Service Card

Relco Products has prepared a one-sheet short form catalog on its five series of heat radiators. Several new models are illustrated with complete performance curves to show heat dissipation. The design of Relco heat radiators permits choice of external transistor mounting, mid-position mounting and internal mounting.

Circle 165 on Reader Service Card

Beryllium oxide, when in the form of a high-density ceramic body, is an electrical insulator and an excelent conductor of heat. Typical values for the electrical, thermal and physical properties of two UOX BeO bodies are provided in new data sheets offered by The Brush Beryllium Company.

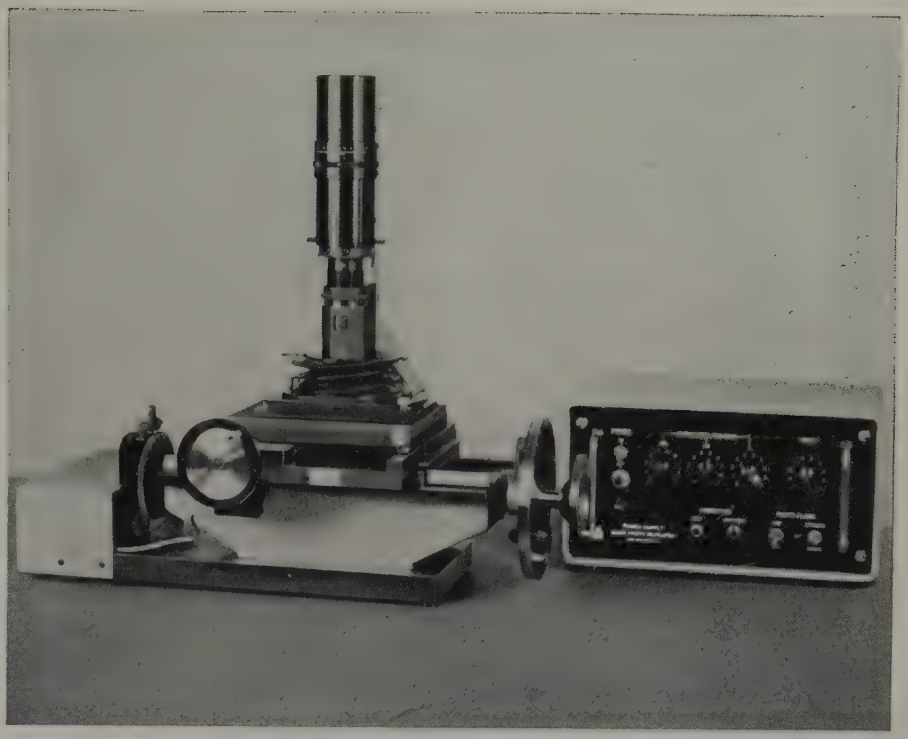
Circle 166 on Reader Service Card

A new full color, 20-page catalog illustrating the Wil-Gard line of protective gloves and finger cots has been published by the Wilson Rubber Co. The publication reports the relative resistance ratings of these glove materials to solutions commonly used in industry. Another chart offers a check on physical characteristics, such as tensile strength and heat resistance. Specifications are listed for the approximate minimum thickness, length, weight, and size of each style, as well as its application to various industries and services.

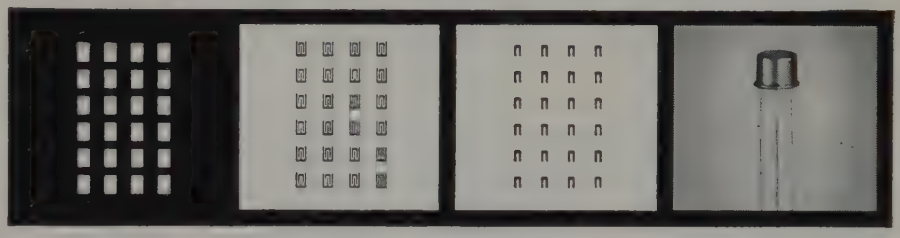
Circle 167 on Reader Service Card

A new catalog of diamond wheels and diamond hones has been published by Norton Company. The catalog contains general information on diamond wheels, recommended starting specifications for a wide variety of work, prices, and a section of wheels for silicon and germanium cutting.

Circle 168 on Reader Service Card



NOW—**PRODUCE YOUR OWN** TRANSISTOR PHOTO-MASKS



The same precision instrument Mann uses in *step-and-repeat* production of photo-masks for transistor manufacturers can now be yours on purchase or lease. The advantages: *Cost and time savings whenever you need new masks; Convenience in experimenting with new types of masks; Complete proprietary security.*

Designed around a two-coordinate comparator, the Mann Photorepeater provides positioning of patterns to an accuracy of 1 micron (.00004″), exact focusing, and precise ratio of reductions. A programming mechanism, capable of performing various combinations of *step-and-repeat* operations, makes exposures automatically. Or, the equipment can be used manually to make specially spaced exposures.

A three-pin plate positioning mount is furnished, so that an aligned series of plates may be accurately positioned and exposed. A mask use fixture of identical configuration makes it possible to insert a series of photo-masks and produce precisely aligned successive exposures of the semiconductor material.

The Photorepeater is available in three basic models—Industrial, Research and Manual. Write or phone for complete details.

DAVID W. MANN COMPANY

A DIVISION OF GEOPHYSICS CORPORATION OF AMERICA
LINCOLN, MASSACHUSETTS—CLEARWATER 9-8015

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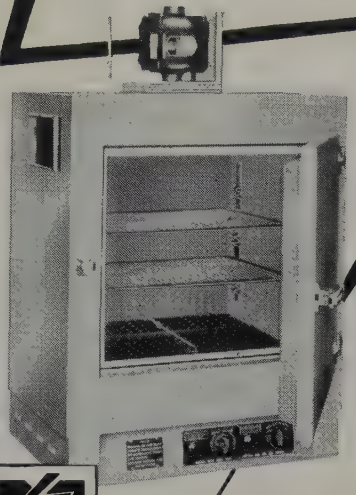
BLUE M STABIL-THERM®
GENERAL
UTILITY OVENS



GRAVITY
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RANGES
to 650° F.
SIZES
1 to 10 cu. ft.

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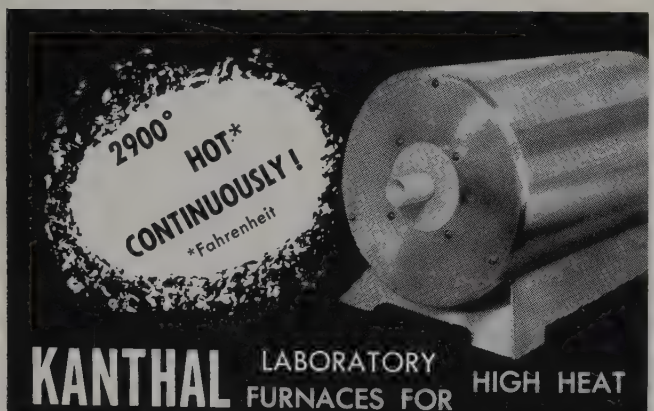

Electric laboratory furnaces, designed for Kanthal Super Cermet Elements and for REH Tubular Elements, provide continuously high temperatures at remarkably low cost.

Kanthal Super Elements provide continuous furnace operating temperatures up to 2700°F and 2900°F in Tubular and Box Furnaces. Furnaces are supplied with platinum-rhodium thermocouples.

Kanthal REH Tubular Elements provide continuous furnace temperatures of 2370°F, and intermittent temperatures up to 2460°F. Type RH-1 tubular furnaces are supplied with thermocouple and safety fuse.

Element	Furnace Type	Chamber Dimensions
Kanthal Super	Box	Up to 12" x 8" x 7"
Kanthal Super	Tubular	Up to 2-3/4" ID x 29" long
REH	Tubular only	IDs of 1-9/16", 2-3/4", or 4" in 7-7/8" or 19-3/4" lengths

Elements and parts available separately. Write for complete data and prices.

KANTHAL THE KANTHAL CORPORATION
19 Amelia Place, Stamford, Conn.
Canadian Rep., Ferro Enamels, Ont. Canada

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Market

Sales

The Bureau of Mines has reported that the production of selenium compounds totaled 208,074 pounds of contained selenium for the first quarter of this year. This was 24% above the fourth quarter last year. The price of commercial-grade selenium was quoted at $6.50 a pound while the high-purity variety was $7.50 a pound during January of this year.

According to the Electronics Division, BDSA, U.S. Department of Commerce, the output of Japanese semiconductors in 1960 totaled over $71 million. This was a 35% increase over the almost $53 million produced the previous year. The output in 1959, however, increased by 114% over 1958. The following statistics also show that 87% of Japanese radios produced last year contained three or more transistors.

Japanese Electronics Production, Annual, 1958-1960

Product	Quantity in thousands of units			Value in thousands of dollars[1]		
	1958	1959 r	1960	1958	1959 r	1960
Semiconductor Devices	....	....	....	24,468	52,893	71,285
Diodes	10,106.7	33,094.9	*44,990.3*	2,657	6,963	7,372
Germanium	n.s.s.	n.s.s.	43,259.5	n.s.s.	n.s.s.	6,318
Silicon	n.s.s.	n.s.s.	1,730.8	n.s.s.	n.s.s.	1,054
Transistors	26,736.3	86,500.5	*139,808.9*	21,354	44,479	*53,847*
Germanium	n.s.s.	n.s.s.	139,636.2	n.s.s.	n.s.s.	53,451
Silicon	n.s.s.	n.s.s.	172.7	n.s.s.	n.s.s.	396
Photo-transistors	12.2	23.5	62.6	46	58	109
Thermistors	1,635.7	8,677.6	9,576.5	411	1,393	1,175
Varistors	n.a.	n.a.	5,320.0	n.a.	n.a.	981
Rectifier elements	n.a.	n.a.	*6,629.9*	n.a.	n.a.	*7,801*
Germanium			106.7			245
Silicon			1,918.3			4,099
Selenium			4,559.6			3,419
Other			45.3			38
Radio receivers, total	4,897.1	*10,025.2*	*12,850.9**	87,088	*156,631*	*194,293**
Tube type	n.s.s.	2,103.5	*1,771.2*	n.s.s.	33,508	*25,113*
Home		n.s.s.	1,679.1		n.s.s.	23,007
Portable		n.s.s.	56.8		n.s.s.	441
Automobile		n.s.s.	35.3		n.s.s.	1,665
With 3 or more transistors	n.s.s.	7,622.8	*11,079.7*	n.s.s.	122,367	*169,180*
Home		n.s.s.	732.8		n.s.s.	13,374
Portable		n.s.s.	10,225.7		n.s.s.	150,958
Automobile		n.s.s.	121.2		n.s.s.	4,848
With less than 3 transistors	n.s.s.	298.9	n.a.	n.s.s.	756	n.a.

[1]U.S. dollar equivalents converted from yen at the rate of 360 yen=$1.00; value data represent factory prices plus excise taxes and royalties, if any.
*Excludes radio receivers with less than 3 transistors.
n.a. Not available. n.s.s. Not shown separately. r data revised.
NOTE: These statistics include only production data from manufacturers employing 20 or more workers. Totals may be understated also because of lack of complete information on production of all products.
Source: Data obtained by the U.S. Embassy, Tokyo, from the Japanese Ministry of International Trade and Industry

Prices

The excessive price slashing which has characterized the semiconductor industry in recent months has caused manufacturers to keenly scrutinize current cost-price ratios to meet a more stable market. Firms are adopting various strategies, in an effort to bring price schedules and operating costs into more realistic alignment such as: consolidation of manufacturing facilities; development of new product lines; dropping of older lines; use of automated techniques; reappraisal of existing accounting procedures, and reexamining marketing practices. Sylvania, for example, is planning to phase out nearly all non-epitaxial lines except germanium mesa and germanium alloy switching transistors. Raytheon plans to drop some of their products such as the older germanium diodes of the joint-contact type in metal cases. Fairchild Semiconductor plans to continue to introduce new products.

Fairchild Semiconductor has reduced the price of its type FT-1310 silicon planar transistor 40% to $12 each in lots of 1-99 and $8.50 each in quantities of 100-999. The EIA has designated this unit the 2N709. It can be packaged in TO-5, TO-18 or micro-block configuration.

News . . .

Suppliers

General Electric Co., is producing its first commercial series of high current silicon rectifiers. These units designated 1N3289 through 1N3295 have peak reverse voltage ratings from 200 to 1,000 v. The 200v model is priced at $9.50 each and the 1,000v model at $44 each.

The Lansdale Division of Philco Corp., has introduced their epitaxial silicon mesa transistors, 2N2086 and 2N2087 for high voltage, high speed, medium power applications. The 2N2086 is priced at $10.95 each from 1-99 units and at $8.03 from 100-999 units. The 2N2087 with a more closely controlled beta, is priced at $11.55 and $8.47 in similar quantities.

Hickok Electrical Instrument Co., has available a portable, fully transistorized in-circuit tester for measuring in-circuit parameters of small and medium power transistors and diodes. This tester lists at $335.

The manufacture of lead telluride, material for use in the operation of the thermoelectric generators which supply auxiliary power to space satellites, was announced by Alloys Unlimited Chemicals, Long Island City, New York. The material is available in n and p types, doped or undoped. Prices are: powdered, $150 to $170 a pound; ingots (14mm dia. x 6" long) $40-$45; square pieces (½" x ½" x 6" long) $67.50 to $75.

Financial

Net income of General Electric Co., dropped 13.3% in the second quarter while sales climbed 1.6% over the same period a year ago. Net profits were $51,002,000 equal to 57¢ a common share, compared with $58,815,000 or 66¢ a share in the like period of 1960. Sales totaled $1,081,803,000 against $1,065,266,000.

General Instrument Corp., had a 3.2% gain in net profits and an increase of 13% in sales for the first fiscal quarter ending May 31, 1961. Sales were $19,220,342 as against $16,983,282 for the comparable period a year ago. Net earnings were $663,076 equal to 27¢ per common share as compared with $642,727, equal to 26¢ per share for the like period in 1960. Corporate backlog of orders as of May 31 was at a high of $53,540,000 up from $44,600,000 in May 1960.

The American Stock Exchange has approved for listing the common shares of Alloys Unlimited, Inc., Long Island City, N.Y., Arrow Electronics, Mineola, N.Y. and Silicon Transistor Corp., N.Y.

Expansion

Sylvania Electric Products Inc., Woburn, Mass., is expanding its Semiconductor Division manufacturing facilities by more than 40%. This expansion program will add 81,000 square feet of manufacturing space to their plants in Woburn and Hillsboro, N.H. The Woburn plant will have more than 220,000 square feet and the Hillsboro plant more than 51,000 square feet.

General Instrument Corporation has established a special Ferro-Electric Ceramic Department at its Newark, N.J. plant and has begun production of ceramic semiconductors and other advanced types of piezo-electric ceramic materials and components for use in military and industrial electronic equipment.

General Electric Co., has broken ground for a $1.5 million, 39,000 square foot computer laboratory in Sunnyvale, Calif. Plans call for its completion by the end of the year.

The Lansdale Division of Philco Corporation has announced the formation of a new Microelectronics Department for the development, manufacture and marketing of highly miniaturized semiconductor circuits. The firm is also shortly planning to re-enter the market with gallium arsenide tunnel diodes after overcoming problems that forced the units back into the laboratory last November.

REDUCE COSTLY KERF LOSSES

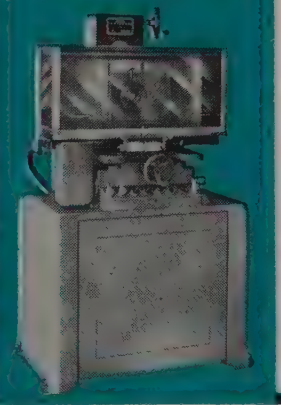
in slicing semiconductor material...

Now . . . switch to 3½" diameter diamond wheels to slice 1" diameter crystals on

Micromech **WAFERING MACHINES**

featuring the ***NEW*** **TYPE 2 CARTRIDGE SPINDLE**

Micromech's newly-designed Type 2 Cartridge Spindle permits the use of thinner, smaller-diameter diamond wheels for slicing germanium and silicon. Provides top wafering efficiency with wheels of *all* sizes, too!



This specially-engineered spindle mounts a 3½" diamond wheel in place of the usual 5" wheel to give from 40% to 100% more slices per 1" diam. crystal . . . reduce kerf loss by 28% to 47%!

Micromech's thinner blades in 3½" diameter size can save from .004" to .009" per slice . . . add up to savings of $200.00 a day!

Moreover, the 3½" wheel allows cutting speeds up to 3" per minute . . . increasing production while decreasing loss of material.

Type 2 Cartridge Spindle is now standard on Micromech hydraulic automatic wafering machines. Write today for detailed information.

FOR QUALITY CONTROL —

Micromech Optical Orientation System

This easy-to-operate system produces accurate visual patterns for identification of principal planes of any single crystal material. No interpretation or correlation data needed. Operator need not be technically trained. Transference of aligned crystal from orientation base to wafering machine table allows accurate cutting of crystal on plane to which it was aligned. Self-contained low-cost unit requires only 2 sq. ft. of table space.

Micromech Diamond Wheels

Micromech stocks 3½" diamond wheels for the economical and fast slicing of all semiconductor materials.

Wheels also available in other popular and odd sizes, DIT and DITRS types. Precision manufacture to close tolerances assures accuracy of cut and long life.

Send for free technical data

MICROMECH MANUFACTURING CORP.

A Division of Sanford Manufacturing Corp.

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Personnel Notes

Election of Maurice Friedman as a Vice President of General Instrument Corporation was announced recently by Martin H. Benedek, Board Chairman. Mr. Friedman, formerly Executive Vice President of the Company's Semiconductor Division, will also serve in the newly created post of Executive Assistant to the President.

Hevi-Duty Electric Company, Watertown, Wis., has announced the appointment of Stuart D. Walker as district manager in charge of a new sales office that has been opened in the Boston area, at 368 Washington Street, Dedham, Mass., to serve the New England states.

Theodore S. Hoffman has been named vice president and manager of the Semiconductor Division of Hoffman Electronics Corporation. He succeeds Dr. Morton B. Prince who has been appointed to the newly created staff position of chief scientist and divisional vice president. Dr. Paul N. Russell, director of technical operations for the Division, has been assigned temporarily to the Evanston, Ill., facilities. Robert L. Sigwell, manager of manufacturing at Evanston, has been promoted to director of operations at that location.

The appointments of two assistant technical directors of Allied Chemical's General Chemical Division were announced by John C. Fedoruk, technical director. They are Charles B. Miller and Dr. Curtis B. Hayworth, both headquartered at the General Chemical Research Laboratory in Morris Township, New Jersey.

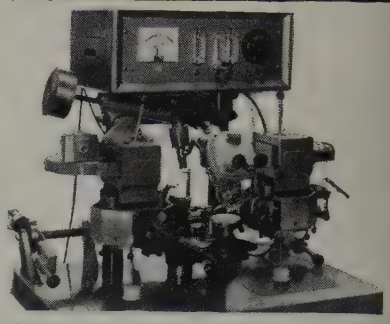
David W. L. Hickie has been appointed manager of marketing for the Lynchburg Operation of the General Electric Company's Rectifier Components Department. He will be responsible for advertising and sales promotion, application engineering, marketing administration, product planning, product sales and customer service for all of the Company's selenium and copper oxide rectifiers.

Dr. Christopher J. B. Fincham has been appointed technical director of the Metals Division, National Research Corporation. Dr. Fincham received his professional degrees from the University of London and has specialized in the physical chemistry of metallurgical systems.

The appointment of two senior sales engineers for the Semiconductor Division of Sylvania Electric Products Inc. has been announced by Roger A. Swanson, Western Regional sales manager for the division. Appointed are William M. Montgomery, who will open a new semiconductor sales office in San Diego, and Lorin C. Weiss, who will be located at Sylvania's sales offices in Los Angeles.

Norman E. Lambert, formerly project engineer with Pacific Semiconductors, has been appointed chief applications engineer, a newly created position at Standard Rectifier Corp. He will have responsibility for instrumentation and custom assembly engineering applications.

K NEWS



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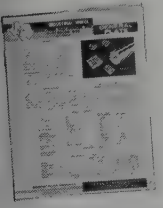

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Dr. Val Kudryk has been elected President of Accurate Specialties Co., Inc. of Hackensack, according to an announcement by Nathan Zimmer, Chairman of the Board of Directors. Dr. Kudryk previously headed High Purity Metals Inc., one of the company's subsidiaries. He will continue in that post.

Lloyd L. Friend has been named Manager of the Saratoga Semiconductor Division of the Espey Mfg. & Electronics Corp. of Saratoga Springs, New York according to a recent announcement by Nathan Pinsley, President of the Corporation. Dr. Friend will handle production of all semiconductor products manufactured by the Division.

Merle J. Davis, a pioneer in research and production in the electronics field, has been appointed sales manager of Anchor Alloys Inc., it is announced by Herbert Drapkin, president. In his new post Mr. Davis is in charge of domestic and world sales for the firm which manufactures alloys and component parts for semiconductor products.

Robert F. English has been appointed sales engineer by Rheem Semiconductor Corporation, it was announced by J. D. Hurley, marketing manager. Mr. English is in charge of the district sales office at 401 Lowell Street, Lexington, Massachusetts. He previously was a sales engineer for Hughes Semiconductor Division. He attended Massachusetts Institute of Technology.

Henry Merino, Jr. has joined Raytheon Company as a sales engineer for the firm's Semiconductor Division. From his office at 6121 Excelsior Boulevard, Minneapolis, he will be responsible for sales and service of Raytheon transistors, diodes, and Circuit-Paks in the Minneapolis-St. Paul area.

SECOA Electronics Corporation, a manufacturer of high power silicon transistors, located at Westbury, L. I., announces the appointment of Frederick M. Sawyer as Manager of Process Engineering. Mr. Sawyer was formerly a transistor Design Engineer at the RCA Semiconductor Division where he was working on the development of industrial silicon power transistors.

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1958—Jan/Feb; March/April; May/June; Nov/Dec.

1959—Dec.

1960—March, May, June, July, Aug., Sept., Nov.

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by George T. Sermon, President
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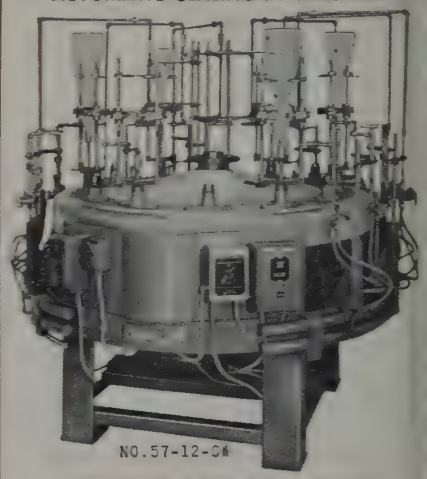

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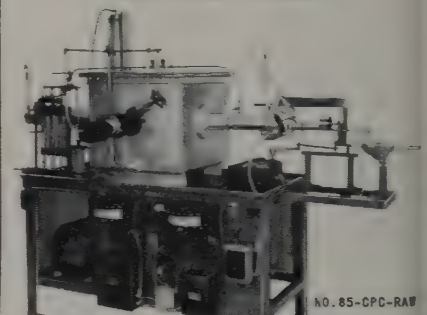

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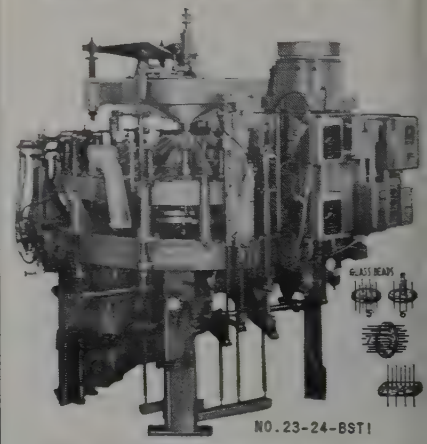

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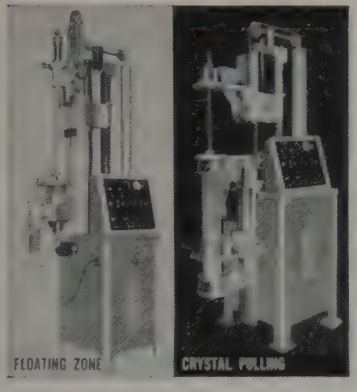

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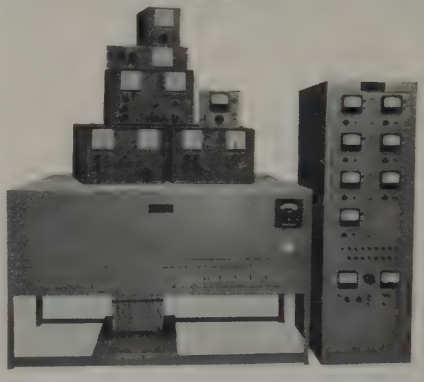

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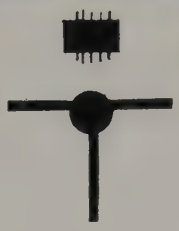

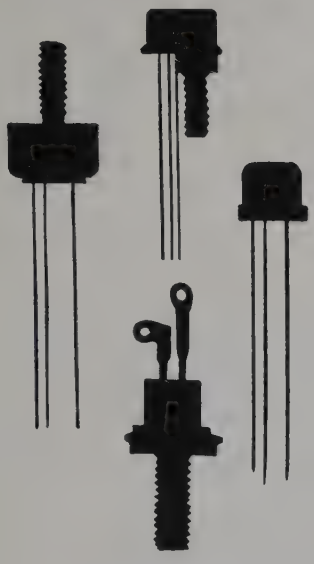

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ELECTRO GRADE HYDROGEN PEROXIDE

	Specification Min.	Max.	Typical Analysis
Assay: H_2O_2 % by weight	30.0 —	32.0	30.0 — 32.0
Free Acid (as H_2SO_4)		.003	.0006
Chloride		.001	.00004
Nitrate		.001	.00008
Phosphate		.015	.011
Sulfate		.0005	.0002
Ammonia		.001	.0006
Heavy Metals (as Pb)		.0001	.00002
Iron		.00005	.00001
pH glass calomel electrode 25°C (Beckman)	3.0 —	3.5	3.3
Stability (24 hrs. 100°C)	95		98

All figures in terms of % by weight unless otherwise noted.

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Here's a new, stabilized 30% Hydrogen Peroxide, specifically developed for transistor etching—Becco Electro Grade H_2O_2, with pH value of 3.0 to 3.5. Made from pure electrolytic H_2O_2, this new peroxide is available in 30- and 55-gallon polyethylene drums to save you many dollars!

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A SIGNIFICANT BREAK-THROUGH IN TRANSISTOR TECHNOLOGY...

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ELECTRO- CHEMICAL DIFFUSED COLLECTOR

The Best High-Power, High-Speed Switching Transistors Ever Developed Provide the Optimum Combination of Voltage, Power, and Speed

The Sprague ECDC Transistor is the first to combine the optimum features of the electro-chemical precision-etch techniques and diffused collector techniques in one highly-mechanized process.

The ECDC Transistor meets these 7 conditions for an "ideal" transistor:

1. Very low collector-to-case thermal resistance through the utilization of high thermal conductivity material as the collector body, resulting in high power dissipation.
2. Thin base width for high radiation resistance and lower storage time.
3. Precision-etched emitter pit permits placement of emitter junction at proper resistivity for optimum breakdown voltage and frequency response.
4. High conductivity surface surrounds emitter pit and close emitter-to-base spacing results in extremely low base resistance.
5. Precision-etched collector provides optimum control of collector series resistance with attendant low saturation voltage, low storage time, and high breakdown voltage.
6. Low collector series resistance as a result of the use of high conductivity material for the mass of the collector area.
7. The structure and manufacturing processes are suited for automated production equipment with immediate in-process feedback.

TYPES 2N2099 & 2N2100

Sprague's new Types 2N2099 and 2N2100 are the first registered types available in the ECDC Transistor family. These P-N-P Germanium Electro-Chemical, Diffused-Collector Transistors are especially designed for high current core driver applications. They feature excellent beta linearity from less than 1 ma to over 400 ma, high frequency response, and low saturation resistance. The low-height TO-9 case is ideally suited to meet equipment designers' needs.

For prompt application engineering assistance, write Commercial Engineering Section, Transistor Division, Sprague Electric Company, Concord, N. H.

For Engineering Data on ECDC Transistors, write Technical Literature Section, Sprague Electric Company, 467 Marshall Street, North Adams, Mass.

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